Appendix 3

KORDI
Korea Ocean Research & Development Institute

Quality Assurance Project Plan (QAPP)

the full scale testing

study for

GloEn-Patrol™ Ballast Water Management System

of PANASIA CO., LTD.

Prepared by

Korea Ocean Research and Development Institute

2nd June 2008

1. Project Management

1.1 Title and Approval Sheet :

Quality Assurance Project Plan (QAPP) for evaluation of the full scale GloEn-Patrol™ ballast water management system of PANASIA CO., LTD.

June. 09. 2008

Mr. Tae-sung Pyo, Project Administrator — **Date**

(PANASIA CO., LTD)

June. 09. 2008

Dr. Kyoungsoon Shin, Project Manager, QA Manager — **Date**

(KORDI)

June, 09, 2008

Mr. Woo-Jin Lee, Technical Representative — **Date**

(KORDI)

June. 09. 2008

Prof. Joon-Wun Kang, Ph.D. — **Date**

Technical Manager for Chemical Analysis

(Yonsei University)

이 창훈

June. 09. 2008

Dr. Chang-hoon Lee, Technical Manager for Toxicity Test
(NeoEnBiz Co.)

Date

Min Ho Jeong

June. 09. 2008

Prof. Min-Ho Jeong, Ph.D., QA Manager
Dong-A University

Date

1.2 Table of Contents

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Prof. Joon-Wun Kang, Ph.D.	Yonsei University Tel) 82 (0)33 760 2494
Dr. Chang-Hoon Lee.	NoeEnBiz Co. Tel) 82 (0)32 670 7210
Prof. Min-Ho Jeong, Ph.D.	Dong-A University Tel) 82 (0)51 240 2865

1.4 Project/Task Organization

This project has three tasks to be done :

1) Perform bio-efficacy test.
2) Conduct ecotoxicity testing on the treated ballast water with the GloEn-Patrol™ Ballast Water Management System.
3) Carry out chemical analysis on the treated ballast water with the GloEn-Patrol™ Ballast Water Management System.

Involved parties to implement this project are shown in Fig. 1.1. Involved parties and roles of this project are detailed below.

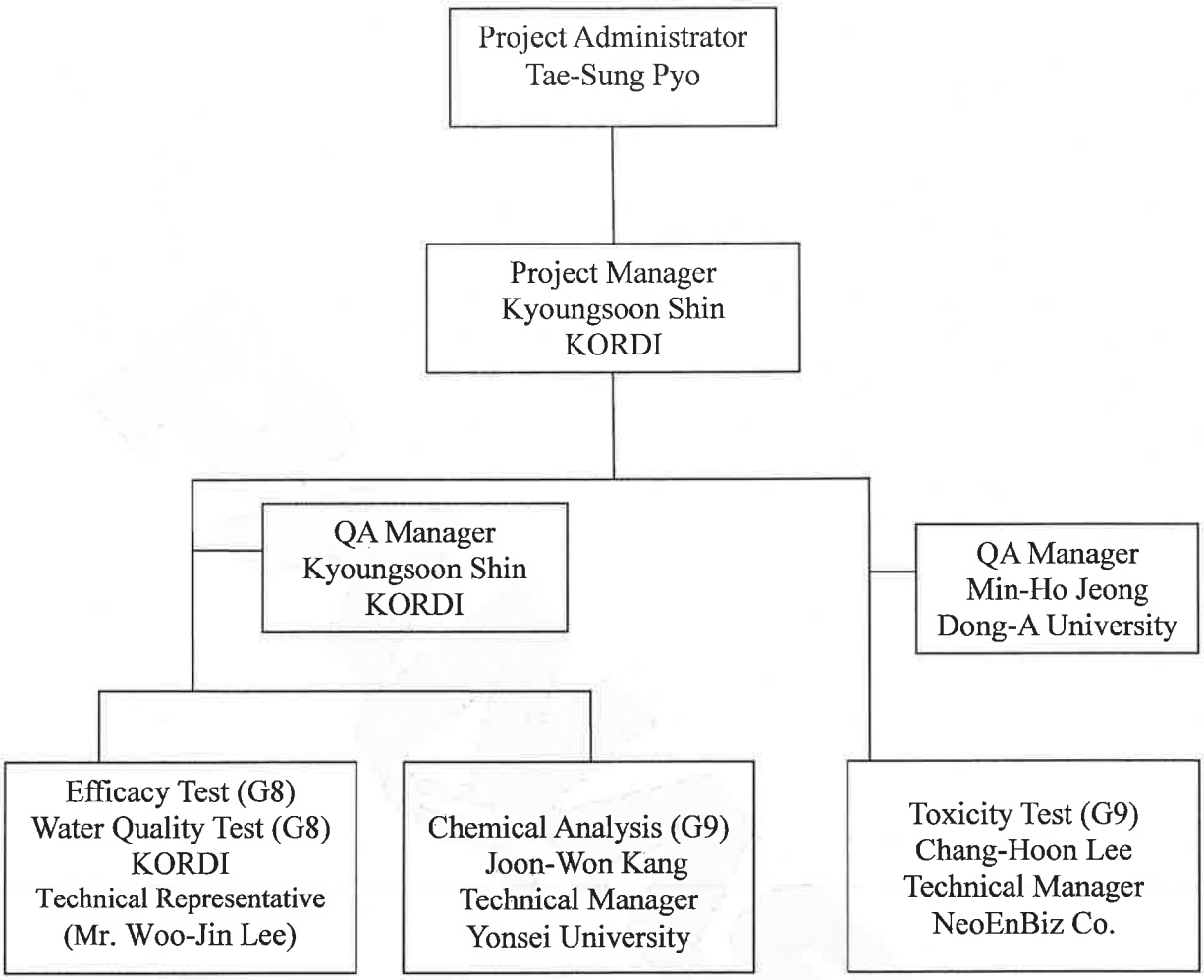


Fig. 1.1 Organizational chart of the project

South Sea Institute of KORDI is the designated Organization for land-based and shipboard testing for type approval of ballast water management systems in the Republic of Korea according to the Provisional Regulation of Type Approval of Ballast Water Management System.

All of the bio efficacy test and chemical measurement at the land-based and shipboard test of ballast water management systems according to the guidelines for approval of ballast water management systems (G8) will be conducted by South Sea Institute of KORDI based on the quality system of ISO/IEC 17025.

■ **Chemical Analysis**

The testing for analysis of relevant chemical and other chemicals using the discharge water at the land-based test as type approval test will be conducted by a joint organization of Yonsei University and SGS testing Korea under internationally recognized guidelines (OECD or equivalent) according to IMO guideline (G9:4.2.3)

Chemical analysis testing for GloEn-Patrol^{TM} Ballast Water Management System will be carried out by a joint of Yonsei University and SGS Testing Korea. Yonsei University will execute the tasks including sampling collection, their handling, transmission under the chain of custody, and analysis of relevant chemical (•OH), H_2O_2, and TRO. SGS Testing Korea will perform testing for other chemicals (i.e. backgrounds and by-products) analysis according to the internationally certified testing manual and reporting the reliable data for the project to Yonsei University.

Overall Project Organization for the chemical analysis testing of the GloEn-Patrol^{TM} Ballast Water Management System (PANASIA Co., Ltd.) is shown in Fig. 1.2.

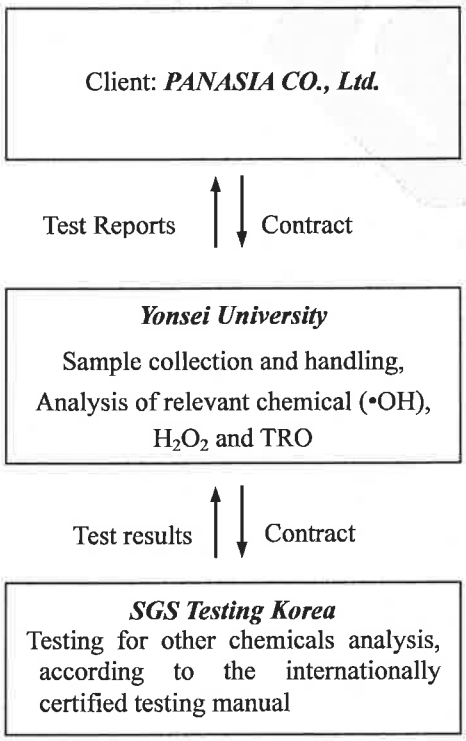


Fig. 1.2 Overall Project Organization for the chemical analysis of the GloEn-Patrol^{TM} Ballast Water Management System (PANASIA Co., Ltd.)

The whole-effluent toxicity (WET) testing using the discharge water samples from the PANASIA test barge for land-based test as part of G8 testing, which is in accordance with the IMO Procedure for Approval of Ballast Water Management Systems that Make Use of Active Substances (G9), as adopted by Resolutions of the IMO Marine Environment Protection Committee . Tests will be carried out by a joint organization of NeoEnBiz Co. and Dong-A University (DAU) Quality Assurance (QA) team, under internationally recognized guidelines (OECD or equivalent) and according to an internationally recognized quality assurance system (GLP).

■ **WET Test**

The whole-effluent toxicity testing of the PANASIA GloEn-Patrol™ Ballast Water Management System comprises two major tasks:

Execution of testing of the samples, which is the responsibility of NeoEnBiz Co.. Quality assurance arrangements and quality inspections, which is the responsibility of DAU QA team.

The overall Project Organization for the G9 toxicity testing is summarized in Fig. 1.3.

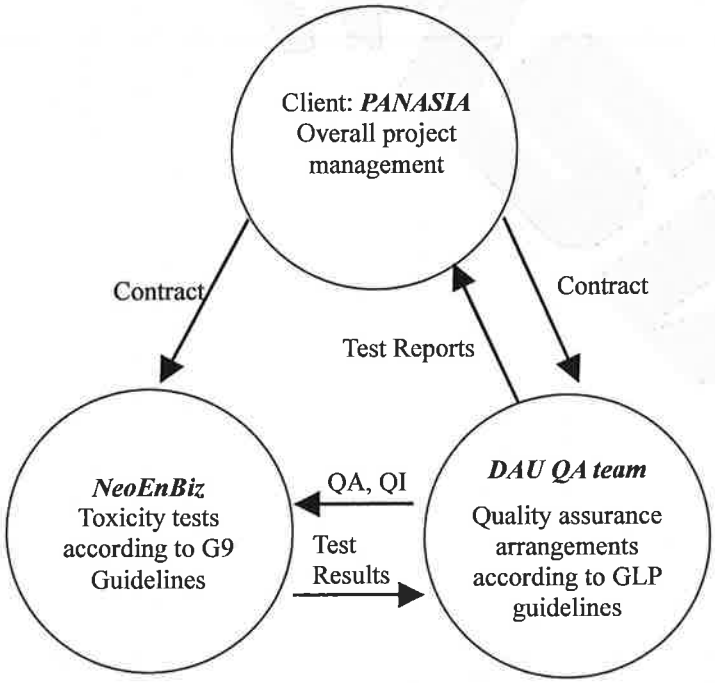


Fig. 1.3 Overall Project Organization for the G9 toxicity testing of the PANASIA GloEn-Patrol™ Ballast Water Management System.

1.4.1 Responsibilities of all Project Participants

Table 1.1 Responsibilities of all project participants

Item		Responsibility	Others
Preparation of test facility		PANASIA Co., Ltd.	
Installation and operation of the treatment system		PANASIA Co., Ltd.	
Fulfillment of the chemical water quality requirement		Technical Representative of KORDI	
Fulfillment of the biological water quality requirement		Technical Representative of KORDI	
Sample collection and preservation		Technical Representative of KORDI	
Clarifying test waters for discharge to recipient waters		Technical Representative of KORDI	
Bio-efficacy test		Technical Representative of KORDI	
Chemical measurements		Technical Representative of KORDI	
Active substances and relevant chemicals test		Technical Manager of Yonsei University	
Toxicity tests		Technical Manager of NeoEnBiz Co.	
Data handling and reporting of test results	Bio-efficacy test & Chemical measurements	Technical Representative of KORDI	
	Active substances and relevant chemicals test	Technical Manager of Yonsei University	
	Toxicity tests	Technical Manager of NeoEnBiz Co.	
Project management and coordination		Project Manager of KORDI	
Quality assurance of project		Quality Representative of KORDI	

1.4.2 Personal Responsibilities

■ **WET Test**

The roles of a joint organization of NeoEnBiz Co. and Dong-A University (DAU) Quality Assurance (QA) team that will work on this project are outlined in Table 1.2

Table 1.2 Project Team Roles in WET Testing

Position	Personnel	Role
Project Scientists of DAU	Min-Ho Jeong	QA Manager
	Wool-Soon Jo	QA Inspector
Project Scientists of NeoEnBiz	Chang-Hoon Lee	Study Director
Assistant Project Scientists of DAU	Eun-Young Kang	QA Officer
	Ji-Nam Kwon	QA Officer
Assistant Project Scientists of NeoEnBiz	Chan-Gyoung Sung	Study Personnel

These roles and responsibilities of each position are described in more detail below.

Project Scientists:

The Project Scientists are responsible for the implementation of laboratory activities, initial data acquisition, health and safety aspects of laboratory activities, and for the proper selection and execution of procedures that have been accepted for use in the investigation. As part of the QA/QC responsibilities, the Project Scientist will:

- Supervise Assistant Project Scientists, technicians, or subcontractors executing data gathering tasks;
- Supervise the regular maintenance of equipment to prevent unnecessary equipment failures and project delays caused thereby;
- Review the effectiveness of procedures and suggest changes that will enhance or more efficiently accomplish the objectives of the study plan;
- Prepare and review laboratory data reductions, reports, submittals, and

presentations to assure that data and conclusions accurately reflect observed conditions;

- Assist in the maintenance of budgetary and scheduling surveillance.

For the Project Manager and Project Scientist who are assigned the role of Study Director, their responsibilities include:

- Being the single point of study control for the relevant set of tests under his/her responsibility
- Approving the study plan for the relevant set of tests under his/her responsibility, including any amendments by dated signature;
- Ensuring that all personnel within his/her team have approved copies of this QAPP and the relevant study plans and SOPs;
- Liaise with the Quality Assurance Coordinator and Officers to ensure compliance with this QAPP and to implement any approved changes;
- Production and approval of the final report relating to the set of tests under his/her responsibility

Assistant Project Scientists:

The Assistant Project Scientists are responsible for assisting in the implementation of laboratory activities, initial data acquisition, health and safety aspects of field activities, and for the proper selection and execution of procedures that have been accepted for use in the investigation. As part of the QA/QC responsibilities, the Assistant Project Scientists will:

- Perform data gathering and compilation tasks.
- Assist in supervising technicians and subcontractors.
- Assist in reviewing the effectiveness of procedures and suggest changes that will enhance or more efficiently accomplish the objectives of the study plan.
- Perform regular maintenance and calibration of equipment to prevent unnecessary equipment failures and project delays caused thereby.
- Assist in the preparation and review of field data reductions, reports, submittals, and presentations to assure that data and conclusions accurately reflect observed conditions.

For those Project Scientists and Assistant Project Scientists that are assigned the roles of

Quality Assurance Inspector and Quality Assurance Officer, responsibilities include, but are not limited to, the following:

- Maintain copies of this QAPP plus all approved study plans and Standard Operating Procedures (SOP) in use in the test facility and have access to an up to date copy of the master schedule.
- Verify that this QAPP and the study plans contain the information required for compliance with the principles of GLP and that this verification is documented.
- Conduct inspections to determine if all studies are conducted in accordance with this QAPP and the principles of GLP.
- Inspect the final reports to confirm that the methods, procedures, and observations are accurately and completely described, and that the reported results accurately and completely reflect the raw data of the studies.
- Promptly report any inspection results in writing to management for action.
- Prepare and sign a statement, to be included with the final report, which specifies types of inspections and their dates, including the phase(s) of the study inspected, and the dates inspection results were reported to management, if applicable. This statement would also serve to confirm that the final report reflects the raw data.

All personnel involved in the conduct of the study must be knowledgeable in those parts of the principles of GLP which are applicable to their involvement in the study, and all study personnel shall:

- Have access to this QAPP and the SOPs applicable to their involvement in the study. It is their responsibility to comply with the instructions given in these documents. Any deviation from these instructions should be documented and communicated directly to the Project Manager.
    - Be responsible for recording raw data promptly and accurately and in compliance this QAPP and the applicable SOPs and are responsible for the quality of their data.
- Exercise health precautions to minimize risk to themselves and to ensure the integrity of the study.
- Communicate to management any relevant known health or medical condition in order that they can be excluded from operations that may affect the study.

■ **Chemical Analysis**

Table 1.3 Project Team Roles in chemical analysis testing

Position	Personnel	Role
Professor of Yonsei University	Joon-Wun, Kang.	Project manager
Ph.D candidate, Yonsei University	Yeon Jung, Jung	Manager
Assistant project scientist of Yonsei University	Yoon Young, Hwang	Technical assistant
SGS Testing Korea, Co., Ltd.	Alen, Lee	Technical manager
SGS Testing Korea, Co., Ltd.	Hoon, Song	Manager

Technical manager is generally responsible for overseeing plan preparation. Technical manager will;

- Approve and review the QA Project plan
- Ensure that the information is accurate and complete;
- Ensure that all appropriate elements are addressed;
- Ensure that the plan identifies the project's technical and quality objectives, and that the intended measurement and data acquisition methods will satisfy these objectives
- Confirm that the planned assessment procedures will be adequate to evaluate the project
- Confirm that there is a process to identify any limitations on the use of the data.
- Determine the impact of any changes on the technical and quality objectives of the project.

Manager and technical assistant will be responsible for the validity and integrity of the data produced. In addition, the Manager and assistant will be responsible for a task related with sampling. Their responsibility will include that;

- Design a tentative sampling schedule and must submit the schedule to the PANASIA Co. Ltd. with the sampling plan. Notify the PANASIA Co. Ltd. a minimum 36 hours prior to the sampling.

- Be performing the tasks for sampling collection, sample integrity and custody, field measurements, and accurate notes.
- Provide a compilation of field notes, deviations from the sampling plan to the laboratory personnel upon completion of all sampling.
- Perform regular maintenance and calibration of equipment to prevent unnecessary equipment failures and project delays caused thereby.
- Perform data gathering and compilation tasks according to all approved study plans and Standard Operating Procedures (SOP)
- Validate and review of field data reductions, reports, submittals, and presentations to assure that data and conclusions accurately reflect observed conditions.

1.5 Project Definition / Background

This project will evaluate environmental effects of GloEn-Patrol™ Ballast Water Management System of PANASIA CO., LTD. For this purpose, ecotoxicity testing and chemical analysis on the treated ballast water will be carried out during efficacy test of GloEn-Patrol™ Ballast Water Management System according to G8 is performed as specified G9, 5.2.1.& 5.2.3. Outcomes of this study/project is test reports from individual parts.Results of toxicity test , chemical analysis and efficacy test will be used for application of final approval of Active Substance.

1.5.1 Presentation of the South Institute of Korea Ocean Research & Development Institute(KORDI)

There are four Institutes at the KORDI (Korea Ocean Research & Development Institute) as Fig. 1.4. South Sea Institute is one of the research stations of KORDI.

Korean Government has prepared for implementation of the IMO Convention. To prepare the tasks regarding the type approval of treatment system, Korean Government notified "Provisional Regulation of Type Approval of Ballast Water Management System" on the Act of Ministry of Maritime Affairs & Fisheries in November 2006. After then, the bill of Law of Ballast Water Management was legislated and enacted on December 2007 to prepare integrated national strategy for the IMO Ballast Water Management Convention.

South Sea Institute of KORDI (Fig. 1.5) is the designated Organization for land-based and shipboard testing for type approval of ballast water management systems in the Republic of Korea according to the Provisional Regulation of Type Approval of Ballast Water Management System. South Sea Institute of KORDI is the operating laboratory that is accredited by KOLAS for ISO/IEC 17025 in field of aquatic organisms at June 2007 and all the bio efficacy tests are conducted by the quality system of ISO/IEC 17025 from October 2006.

South Sea Institute of KORDI is requested the type approval test of the ballast water management system of the GloEn-Patrol^{TM} from PANASIA CO.,Ltd. at May 2008 which is granted basic approval of active substances from IMO.

So, South Sea Institute of KORDI construct the testing organization preparing for the type approval test for Korean Government and gathering information for final approval of active substances.

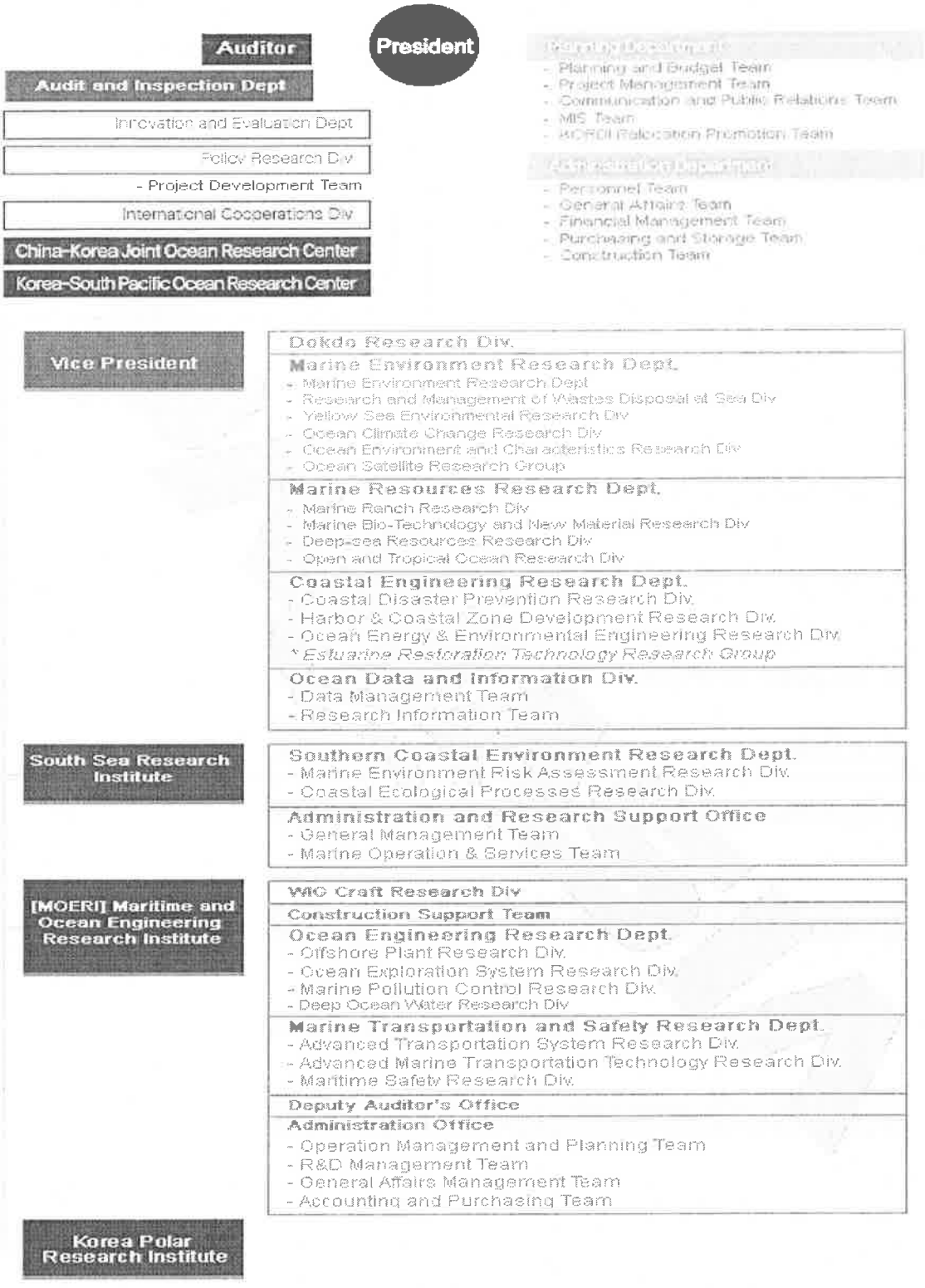


Fig. 1.1 Organization of the KORDI

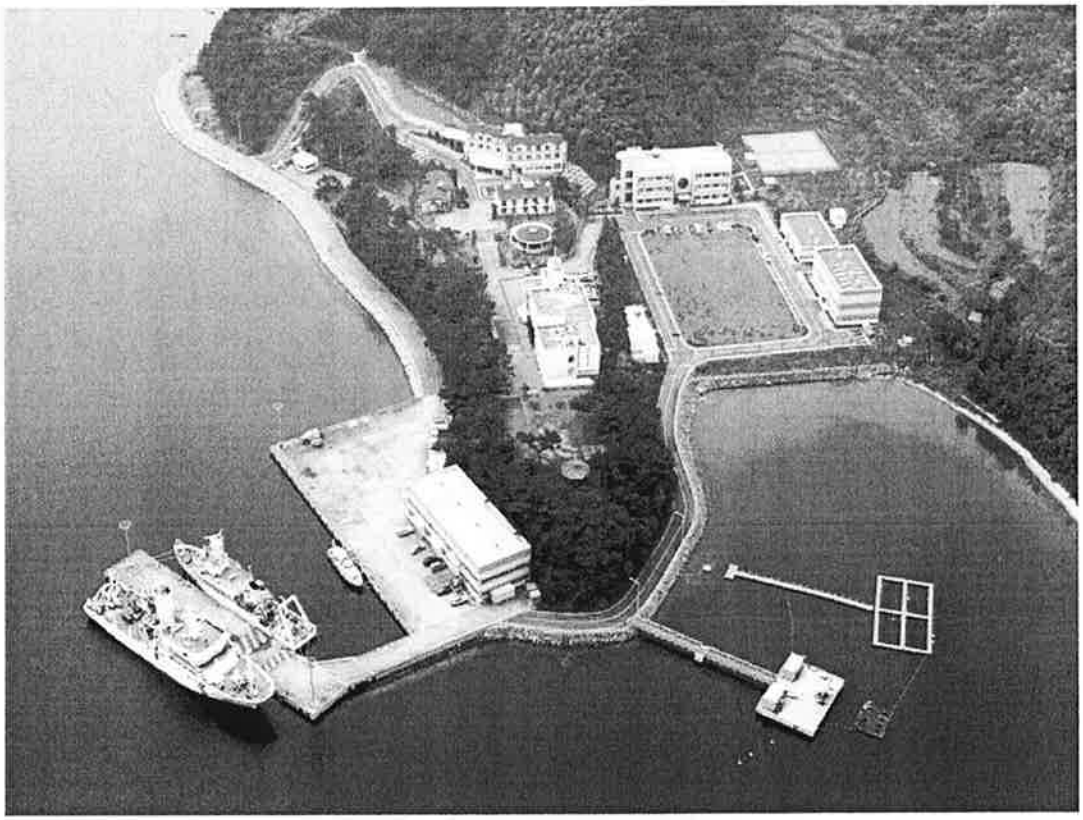


Fig. 1.2 South Sea Institute of KORDI

Yonsei University and SGS Testing Korea is requested the residual testing of relevant and other chemicals in the water samples discharged from the GloEn-Patrol™ Ballast Water Management System (PANASIA Co., Ltd.) for land-based test as part of G8 testing at May 2008. Yonsei University has a specific duty in •OH residual testing and analysis of low level of hydrogen peroxide in water sample, employing a specifically designed experimental methods based on its accumulated experience in that field (Han et al., 2002a; Han et al., 2002b; Nam et al., 2003; Oh et al., 2005).

SGS Testing Korea is the a expertise organization for analysis of organic and inorganic substances in environment samples, which is accredited by KOLAS (Korea Laboratory Accreditation Scheme) as testing laboratory in accordance with the provisions of Articles 23 of the National standards Acts for ISO/IEC 17025:2005. In addition, SGS Testing Korea is certificated by NELAP (National Environmental Laboratory Accreditation Program) from June 2006 to Jung 2009 which is the program that implements the NELAC (National Environmental Laboratory Accreditation Conference) standards, States and Federal agencies

as accrediting authorities with coordination currently facilitated by USEPA to assure uniformity. Therefore, Yonsei University and SGS Testing Korea perform the test for analysis of relevant chemical and other chemicals in the discharge water samples treated by GloEn-Patrol™ Ballast Water Management System.

2 PROJECT DESCRIPTION

2.1 Address of QAPP

This QAPP describes the implementation of quality assurance and quality control activities during the evaluation of the GloEn-Patrol™ according to the requirements for chemical testing stated in the IMO guidelines for Approval of Ballast Water Management Systems (G8).

All of the tests will be conducted based on the quality system of ISO/IEC 17025 of South Sea Institute of KORDI. The analysis at Yonsei University and NeoEnBiz Co. will be conducted according to the standard procedures keeping all of the document and records. All of the laboratories are established and maintained procedures for identification, collection, indexing, access, storage, maintenance and disposal of quality and technical records as a quality assurance document.

South Sea Institute of KORDI is the operating laboratory that is accredited by KOLAS for ISO/IEC 17025 in field of aquatic organisms and all efficacy tests are conducted by the quality system of ISO/IEC 17025.

Detail plan refer to the Quality Manual of ISO/IEC 17025 System at South Sea Institute of KORDI.

■ **Chemical Analysis**

SGS Testing Korea is accredited by KOLAS (Korea Laboratory Accreditation Scheme) as testing laboratory in accordance with the provisions of Articles 23 of the National standards Acts for ISO/IEC 17025:2005 and also certificated by NELAP (National Environmental Laboratory Accreditation Program) from June 2006 to Jung 2009. The analytical procedures and associated quality control criteria for the tests performed by SGS Testing Korea are followed by the SOPs written by SGS Testing Korea based on USEPA method for each parameter.

In addition, Yonsei University has a specific duty in •OH residual testing and analysis of low level of hydrogen peroxide in water sample, employing a specifically designed experimental

methods based on its accumulated experience in that field (Han et al., 2002a; Han et al., 2002b; Nam et al., 2003; Oh et al., 2005). Since the internationally recognized guideline for analysis of •OH in water on as a part of IMO G9 (4.2.3) is not available from OECD or equivalent, •OH residual testing will be performed by the procedures based on relevant references that current methods for detecting and quantifying •OH in water are described.

All the data generated for this project will be evaluated on the basis of its precision, accuracy, completeness, representativeness and comparability. Any data falling outside of the established acceptance criteria for these five quality control parameters will be rerun after the potential sources of error have been investigated, corrected and documented. Yonsei University and SGS Testing Korea will follow its routine quality assurance program to accomplish these quality assurance goals and will incorporate any additional quality control protocols.

■ **WET Test**

This part of QAPP has been developed in order to provide the detailed quality assurance arrangements for the toxicity testing of the whole-effluent from the PANASIA GloEn-Patrol^{TM} Ballast Water Management System, in accordance with the IMO G9 Procedures.

As the G9 Procedure does not provide any guidance as to the structure, format and content of the required QAPP (except to refer to generic international standards), and as such guidance is not available from IMO, DAU QA team has used the following as guidance for their QAPP:

- US EPA Requirements for Quality Assurance Project Plans (EPA QA/R-5)
- US EPA Guidance for Quality Assurance Project Plans (EPA QA/G-5)
- as well as the existing Standard Operating Procedures (SOP) of DAUH-CRC, which are based on Principles of Good Laboratory Practice (GLP) of the Korea Food and Drug Administration (KFDA, Bulletin No. 2005-79), as per their principles of GLP of the Organization for Economic Cooperation and Development (OECD, 1997)

Because the EPA guidance on QAPPs is highly generic, and not designed specifically for toxicity testing of treated ballast water or with the IMO G9 Procedures in mind, in some sections the organization of this QAPP may differ slightly from the EPA guidance, in order to

fit the purpose at hand.

This QAPP provides guidance and specifications to assure that:

- proper preventive maintenance, equipment calibration and approved analytical protocols will be implemented so that all laboratory measurements and analytical results will be valid;
- records are produced and retained to document the validity of applied procedures and the completeness of the investigation in relation to the approved scope of the project;
- generated data is validated; and
- calculations, evaluations, and decisions completed or deduced during the execution of the study are accurate, appropriate, and consistent with the objectives of the Study Plans

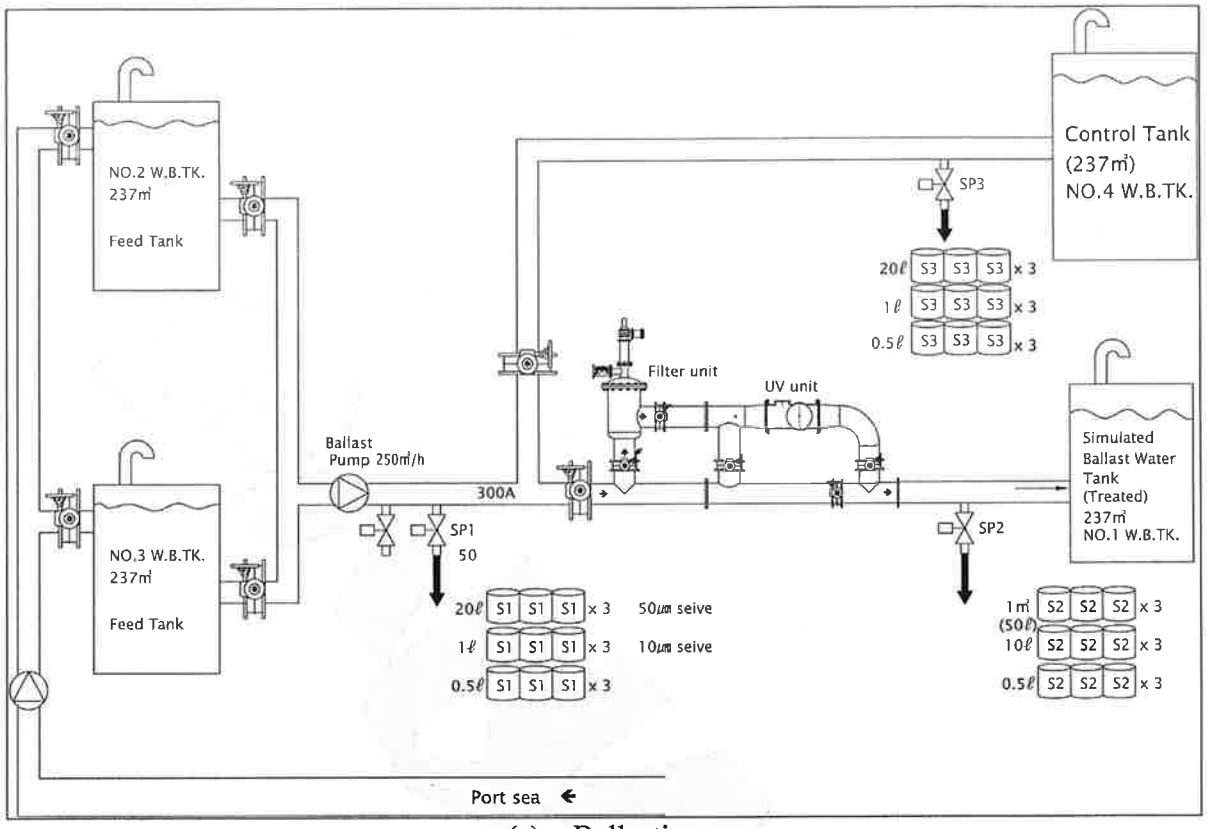
The requirements of this QAPP are applicable to the activities of all participants in the testing and this QAPP addresses all anticipated activities necessary to execute the testing

2.2 Process to be Evaluated

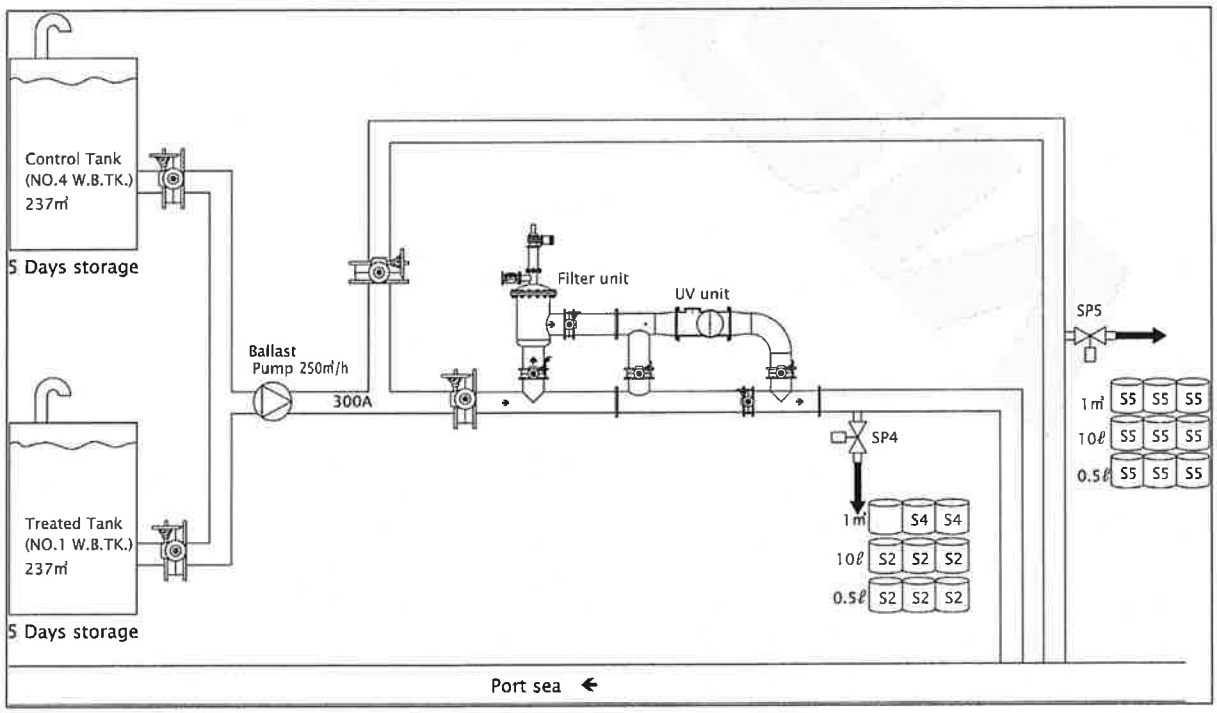
2.2.1 Conducting of Tests

The efficacy of ballast water management systems, which make use of active substances possible, will be evaluated by administration in accordance with guidelines for approval of ballast water management systems (G8). The guidelines (G8) include general requirements concerning design and construction, technical procedures for evaluation and the procedure for issuance of the Type Approval Certificate of ballast water management system. The guidelines (G8) are unique compared to the requirements for type approval of traditional marine equipment as type approval of Ballast Water Management Systems requires both land-based and shipboard test.

The procedure and conditions of land-based test is described at Fig. 2.1. Details of procedure are shown in section 3.2.



(a) Ballasting



(b) Discharge

Fig. 2.1 Land-based test procedure and conditions

■ **Chemical Analysis**

The testing for analysis of relevant and other chemicals in the water samples treated by the GloEn-Patrol^{TM} Ballast Water Management System will be conducted at the same time with the toxicity test, which will be immediately after treatment (first-day), the middle (after three day storage), and the end of five-day period (after five days storage) required in G8. Yonsei University is responsible for sampling collection, sample integrity and custody, field measurements, and accurate notes. A compilation of field notes, deviations from the sampling plan will be provided to the laboratory personnel of SGS Testing Korea and Yonsei University upon completion of all sampling. In addition, testing for analysis of relevant chemical (•OH), hydrogen peroxide (H2O2) and total residual oxidant (TRO) in the test water samples are the responsibility of Yonsei University. SGS Testing Korea is responsible for analysis of backgrounds (i.e. anions, total organic carbon and chemical oxygen demand) and other chemicals including by-products (i.e. TCE, PCE, THMs, HAAs, and TOX) and the quality control for the data generated for the project.

■ **WET Test**

The G9 testing of the whole-effluent from the PANASIA GloEn-Patrol^{TM} Ballast Water Management System will be conducted immediately after treatment, at the middle (three-day), and at the end of five-day period required in G8.

Tasks including collection of effluent samples, their handling and transmission under chain of custody, and execution of toxicity testing are the responsibility of NeoEnBiz Co.. The quality assurance arrangements for these tasks are the subject of this QAPP developed by DAU QA team.

2.2.2 Reporting of Results

At the end of the project ,the report will be separately published by KORDI, SGS Testing Korea, Yonsei University and NeoEnBiz Co.. Bio-efficacy test results will be published by KORDI, test results of active substances and relevant chemicals will be published by Yonsei University , chemical analysis results will be issured by SGS Testing Korea and toxicity test results will be published by Dong-A University (NeoEnBiz Co.). Interim report on efficacy

test can be generated.

2.3 Quality Management Plan (QMP)

South Sea Institute of KORDI is the operating laboratory that is accredited by KOLAS for ISO/IEC 17025 in field of aquatic organisms and all efficacy tests are conducted by the quality system of ISO/IEC 17025. KOLAS (The Korea Laboratory Accreditation Scheme) is the governmental accreditation body in Republic of Korea. KOLAS evaluates the technical competence of testing and calibration laboratories based on the general requirements of ISO/IEC 17025, general requirements for the competence of testing and calibration laboratories and specific technical requirements of each field .

All of the document (Quality Manual, Quality Procedure and Quality Guideline) can be presented if necessary to the relevant persons.

■ **Chemical Analysis**

SGS Testing Korea is accredited by KOLAS (Korea Laboratory Accreditation Scheme) as testing laboratory in accordance with the provisions of Articles 23 of the National standards Acts for ISO/IEC 17025:2005 and is certificated by NELAP (National Environmental Laboratory Accreditation Program) from June 2006 to Jung 2009. Yonsei University has a specific duty in •OH residual testing and analysis of low level of hydrogen peroxide in water sample, employing a specifically designed experimental methods based on its accumulated experience in that field (Han et al., 2002a; Han et al., 2002b; Nam et al., 2003; Oh et al., 2005). Therefore, quality assurance and test procedures described in this QAPP are based on standard operation procedures (SOPs) and quality manual (KS A ISO/IEC 10275) of SGS Testing Korea.

■ **WET Test**

The quality assurance procedures described in this QAPP are based on Standard Operating Procedures (SOPs) of Dong-A University Hospital Clinical Research Center (DAUH-CRC), principles of Korea Good Laboratory Practice (KGLP) of the National Institute of Environmental Research, principles of GLP of the Organization for Economic Cooperation

and Development, and relevant guidelines of United States Environmental Protection Agency and the American Society for Testing and Materials (ASTM).

GLP accreditations held by the DAUH-CRC are as follows:

- Korea Food and Drug Administration, Certification No. 16, 2005 (www.kfda.go.kr)
- National Institute of Environmental Research, Certification No. 12, 2007 (http://eng.nier.go.kr)
- Rural Development Administration, Certification No. 2, 2007 (www.rda.go.kr)

2.4 Presentation of the Vendor

Vendor : PANASIA CO., LTD
Address : #1559-3, Songjung-Dng, Gangseo-Ku, Busan, Korea
Tel : +82 (0) 51 831-1010
Fax : +82 (0) 51 831 1399
e-mail : design21@pan-asia.co.kr, panasia@pan-asia.co.kr

3 EXPERIMENTAL APPROACH

3.1 Description of Test Site and Technology Set-Up

3.1.1 Test Facilities

The test facility is installed on a special barge that has been designed and manufactured to meet IMO's requirement for the land based-test. It has length of 44 meters, a width of 14 meters, a height of 3.3 meters and has four(4) ballast tanks which has a capacity of 237 respectively . Two of them are used as control tank (No. 4 W.B.TK) and simulated ballast tank (No. 1 W.B.TK) during the type approval test according to G8 guideline and the others are used for culture tanks/dosing tanks (No. 2 & 3 W.B.TK).

Cultured organisms are poured into test water in No. 3 & 4 ballast water tanks to meet concentrations. The ballast tanks was pressure-washed with tap water by general service pump on the barge after each test and dried more than at least one(1) day between test cycles. Internal structures conform to ship's practice. The ballast pumps are centrifugal type, the piping is galvanized steel pipe.

The GloEn-Patrol™ Ballast Water Management System treats the ballast water both on uptake and at discharge. At discharge the ballast water passes the UV unit only and the filter unit is bypassed to avoid backflushing water from the filter unit.

The test facilities for land-based test are described at Fig. 3.1 and Fig. 3.2.

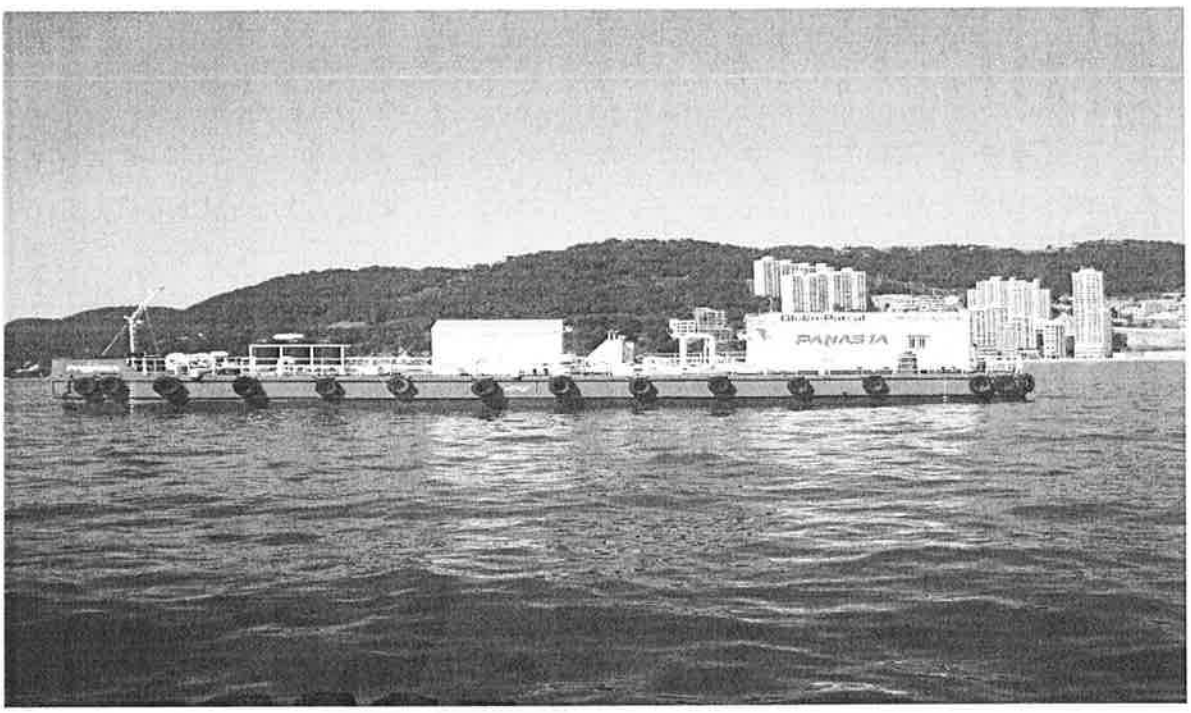


Fig. 3.1 The barge for land- based test

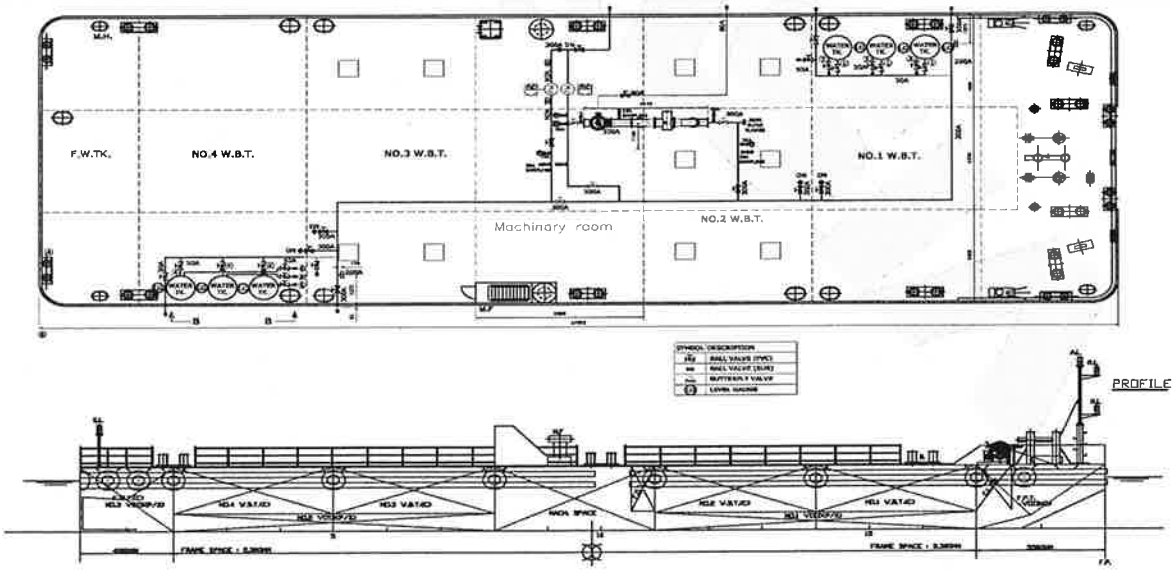


Fig. 3.2 Test facilities for land- based test

3.1.2 GloEn-Patrol™ Ballast Water Management System

The PANASIA Ballast Water Management System (called the " the GloEn-Patrol™ Ballast System" hereinafter) for land based test consisted of filtration unit, a UV unit, and Monitoring and Control Panel (called the "control panel" hereinafter) as specified below.
The whole system (the filter unit and the UV unit) is connected in series to the pipeline, and treats the ballast water as it passes through the system.

- Filtration system as a pre-treatment
  Flow rate: 250 m^3/hr
  Filtration degree: 50 microns
  Working pressure: 2.5 bar
  Material
  - Filter housing : SS 316L
  - Filter screen : SS 316L
  - Cleaning mechanism: SS 316L

- UV disinfection system as a main treatment installed with:
  UV chamber (SS316L, flow rate 250 m^3/hr)
  Medium pressure UV lamps
  UV monitor
  Temperature sensor
  Automatic washing wiper for quartz sleeves
  Operating UV Dosage: 300 -350 mJ/cm^2

The filter is installed on the discharge side of the ballast water pumps, and is fully automatic in terms of cleaning without affecting the filtration process. The first stage, the filter significantly reduces the sediment load of the ballast water and also removes some of the microorganisms.

The UV unit employs medium-pressure ultraviolet (MPUV) lamps to destroy living microorganisms present in the liquid being treated. The unit includes electromagnetic ballasts and an automatic, in-place mechanical cleaning system capable of cleaning the lamps while

disinfecting. Each lamp is enclosed in an individual quartz sleeve.

The treatment is achieved by passing liquid through a stainless steel chamber containing several UV-emitting arc-tubes. The arc-tube is mounted in a quartz sleeve and fitted within the chamber, allowing the liquid to pass the sleeve/thimble on all sides.

The GloEn-Patrol™ Ballast System treats the ballast water both on uptake and at discharge. At discharge the ballast water passes the UV unit and the filter unit is bypassed to avoid filter backflushing.

The whole system (the filter unit and the UV unit) is connected in series to the pipeline to treat water as it passes through the system

3.2 Technology Start-Up and Stop Procedures

3.2.1 The Day(Day 0) of Tests

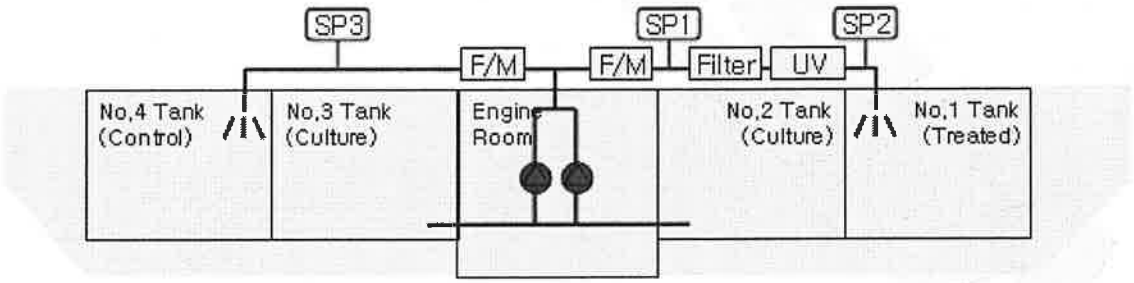


Fig. 3.3 Schematic of ballasting

- **Start-Up Procedure**
  1) Check the quality of water and concentration of organisms by sampling water from No.2 & No.3 ballast tanks against D2, before starting test.
  2) Start two ballast pumps at the same time and start GloEn-Patrol™ Ballast System after flow rate reaches at 250m^3/hr.
  3) Keep on checking level gauge of No.2 & No.3 ballast tanks continually, collect samples at sample point SP1, SP2 and SP3 respectively when water is transferred at

20%, 50% and 80% in No.2 & No3 ballast tanks.

■ **Stop Procedure**

1) Confirm the level gauges if the water in No.2 & No3 ballast tanks is transferred.
2) Switch GloEn-Patrol™ Ballast System.
3) Stop two pumps.
4) Close the valve for No.2 & No.3 ballast Tanks.

3.2.2 After 5 Days (Treated)

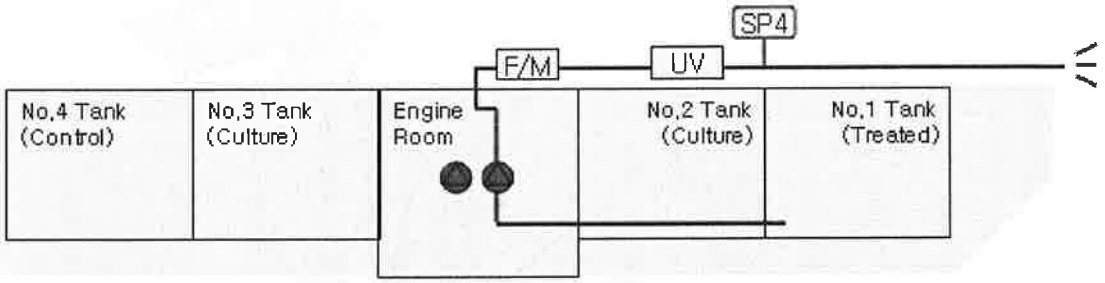


Fig. 3.4 Schematic of discharge(Treated)

■ **Start-Up Procedure**

1) Open the valve for No.1 ballast tank.
2) Start up for ballast pump.
3) Switch on GloEn-Patrol™ Ballast System (Only UV unit).
4) Keep checking flow rate over flow meter.
5) Keep on checking the level gauge of No.1 ballast tank continually, collect samples at sample point SP4 when water is transferred at 20%, 50% and 80% in No.1 ballast tank.

■ **Stop Procedure**

1) Confirm the level gauge if the water in No.1 ballast tank is transferred.
2) Switch off GloEn-Patrol™ Ballast System.
3) Stop the pump.
4) Close the valve for No.1 ballast tank.

3.2.3 After 5 Days (Control)

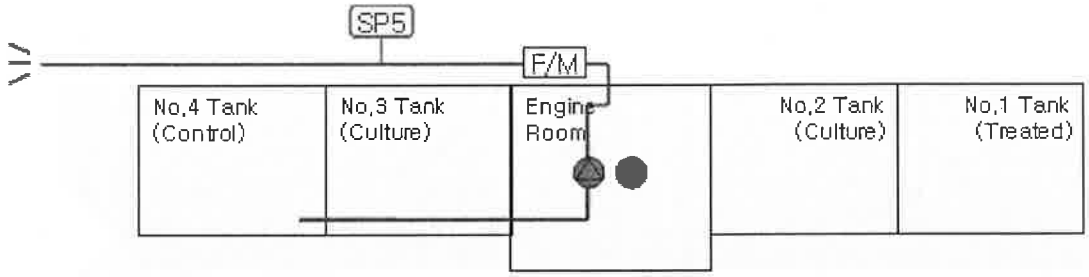


Fig. 3.5 Schematic of discharge(Control)

■ **Start-Up Procedure**

1) Open the valve for No.4 ballast tank.
2) Start up for ballast pump.
3) Keep checking flow rate over flow meter.
4) Keep on checking the level gauge of No.4 ballast tank continually, collect samples at sample point SP5 when water is transferred at 20%, 50% and 80% in No.4 ballast tank.

■ **Stop Procedure**

1) Confirm the level gauge if the water in No.4 ballast tank is transferred.
2) Stop the pump.
3) Close the valve for No.4 ballast tank

3.3 Emergency Plan

3.3.1 Clogging Fault

The Differential Pressure Switch (DPS) constantly monitors the pressure differential between the inlet and outlet of the filter. When the DPS senses a preset value (usually 0.35 bar=5 PSI)

there is a delay of three(3) seconds before the flush cycle begins. At the end of the cleaning cycle, if the pressure differential signal remains, the filter will continue to clean itself for 15 minutes before entering into malfunction mode.

DP fault occurs when there is a continuous DPS signal for more than 15 minutes. In this case the flushing cycle stops, the fault light turns on and the fault output is activated. The fault output of 24VAC can activate an alarm system, automatic bypass, pump shutoff, etc.

3.3.2 Loss of Water Flow and UV Chamber Temperature

The UV-lamps produce a considerable amount of heat that is removed if the flow-rate of the liquid passing through the system is high enough. In order to monitor the temperature of the liquid, a temperature detector is fitted in the UV-system so that unsafe situations caused by possible breakdowns can be prevented.

As soon as the liquid temperature exceeds the pre-set value (default value: 45℃), an alarm is given and the system shuts down.

The lamps are placed in quartz sleeves and therefore do not come into direct contact with the liquid. They can be fitted from either flanges. This has to be done according to a strict procedure.

3.4 Preparation of Test Waters

3.4.1 Assurance of Fulfillment of Chemical Water Quality Test Criteria

Land-based tests under adjacent salinity ranges should be separated by at least 10 psu according to the Guideline G8 by IMO. Tests will be performed in the coast of Busan (> 32 psu) and downstream of the Nakdong River (3~32 psu). The soluble lignin, starch (or seaweed powder) and kaolin (or prepared mud) will be added to adjust the contents of dissolved organic carbon (DOC), particulate organic carbon (POC) and total suspended solids (TSS) respectively, to satisfy the limits of chemical water quality criteria.

3.4.2 Assurance of Fulfillment of Biological Water Quality Test Criteria

.1 Harvesting of Indigenous Organism

Indigenous organisms will be harvest by plankton net (mesh size: 7 and 45 μm, mouth diameter: ca. 20 cm). Plankton nets will be hauled up vertically by winches prior to the test to adjust the sufficient plankton population according to the Guideline G8. The collected organisms will be transferred to a tank that fills with more than 50 tons of ambient water. Commercially available f/2 culture media will be added to collected ambient water.

.2 Cultivation of *Artemia salima, Brachionus rotundiformis, Amphidinium carterae* and *Tetraselemis* spp.

***Artemia* spp. (>50 μm)**

Dried eggs of *Artemia salina* will be purchased from INVE Aquaculture in Belgium. 700 g of dried eggs will be cultivated using 500 L of filtered (1μm pore size, CP filter) natural sea water under conditions specified below.

- pH: 8~9
- Temp.: 23~27℃
- Salinity: 15~33 psu
- Light intensity: over 2000 lux
- Photo period, L: D=24:0
- Aeration: DO= > 9.0mg/L

***Brachionus rotundiformis* (>50 μm)**

These species are maintained at the AQUANET Co. LTD and mass cultured for the commercial distribution under conditions specified below.

- pH: 7~8
- Temp.: 28~32℃
- Salinity: 28~30 PSU
- Aeration: DO= 12mg/L

- Feeding: Chlorella sp. (Daesang Co. Ltd)

***Amphidinium carterae* and *Tetraselmis* spp. (10~50μm)**

These species are maintained at the NLP (Natural Live Plankton Co. LTD) and mass cultured for the commercial distribution under conditions specified below.

- Media: f/2 medium
- Temp.: 20~23℃
- Salinity: 17~33 PSU
- Light intensity: over 2700 lux
- Photo period, L: D=10:14
- Culture media volume: 500L x 2

.3 Bacteria

Heterotrophic bacteria occur more than 10^4 cells/ml through the year in the coast of Busan and downstream of the Nakdong River. The abundance of heterotrophic bacteria will be enumerated prior to the test to determine the sufficiency of cell density according to the Guideline G8.

3.4.3 Discharge of Waters

This system is operated during ballasting and discharge and holding time of the treated ballast water is not necessary. Therefore water transferred to the control tank will be directly discharged to the ambient environment and water transferred to the treated tank will be discharged after treatment again.

3.5 Running Test Cycles

It will follow the Guideline G8 by IMO described as Fig. 2.1 at Chapter 2.2.

3.6 Sampling and Measurements

Sampling procedures and measurements are shown in Table 3.1.

Table 3.1 The procedures of sampling and measurements

Parameter	Procedures of sampling	Measurements
Temperature	20L of water sample are collected to a clean bucket at the sampling pipe lines	See. Section 5.1.1
Salinity	〃	See. Section 5.1.1
Dissolved oxygen	〃	See. Section 5.1.2
pH	100mL of water sample are collected to a new polyethylene bottle at the sampling pipe lines	See. Section 5.1.3
> 50μm sized organisms	It will follow the Guideline G8 by IMO	See. Section 5.2.1
10 ~ 50μm sized organisms	〃	See. Section 5.2.2
Heterotrophic bacteria (DAPI)	〃	See. Section 5.2.3
Escherichia coli (*E. coli*)	100mL of subsample from 2L of water sample collected to the sterile bottle at the sampling pipe lines	See. Section 5.2.4
Enterococcus group	100mL of subsample from 2L of water sample collected to the sterile bottle at the sampling pipe lines	See. Section 5.2.5
Vibrio cholerae	100mL of subsample from 2L of water sample collected to the sterile bottle at the sampling pipe lines	See. Section 5.2.6
DOC	200mL of subsample from 2L of water sample collected to the sterile bottle at the sampling pipe line	See. Section 5.3.1
POC	200mL of subsample from 2L of water sample collected to the sterile bottle at the sampling pipe line	See. Section 5.3.2
TSS	500mL of subsample from 2L of water sample collected to the sterile bottle at the sampling pipe line	See. Section 5.3.3

3.7 Time Schedule for the Testing Period

The test will be carried out when chemical and biological requirements of test water fulfill the condition specified to Guideline G8. Test water split into control water and treated water during the initial test will be stored in the control tank and treated tank respectively, for 5

days before the end of test. The starting date will be decided depending on the density of organism and the condition of cultivated organism in the test sites (Busan and the Nakdong River).

Test schedule is shown in Table 3.2.

Table 3.2 Schedule of test procedures

Test Cycle	Date		Test Water	Sampling		
				For Land-based Test	For Toxicity Test	For Chemical Analysis
1	Day 0	2008.07.24	Seawater	O		O
	Day 3	2008.07.27				O
	Day 5	2008.07.29		O		O
2	Day 0	2008.08.08	Seawater	O	O	O
	Day 3	2008.08.11			O	O
	Day 5	2008.08.13		O	O	O
3	Day 0	2008.09.24	Brackish Water	O		
	Day 5	2008.09.29		O		
4	Day 0	2008.10.01	Brackish Water	O	O	O
	Day 3	2008.10.04			O	O
	Day 5	2008.10.06		O	O	O
5	Day 0	2008.10.08	Brackish Water	O		
	Day 5	2008.10.13		O		
6	Day 0	2008.10.15	Seawater	O		
	Day 5	2008.10.20		O		

4 SAMPLING PROCEDURES

4.1 Representativeness of Samples

Water in the culture tank will be mixed using an aeration system to evenly distribute particulate contents. Water in the tanks will be discharged through the pipeline installed under the bottom of each tank. In other words, there will be no water left in the tank after discharging. Samples will be collected as stated in the Guideline G8 by IMO while each tank uptakes and/or discharges water at the beginning, middle and end of test.

4.2 Sampling of Test Waters

■ **Bio Efficacy Test**

Samples taken as stated in the Guideline G8 by IMO must be representative of the volume and nature of test, control and treated water. Samples will be identified as test, control and treated water. Sampling items will be identified as "temperature, salinity, pH, TSS, POC, DOC, 10~50 μm fractionized organisms, > 50 μm fractionized organisms, heterotrophic bacteria, and *Escherichia coli* (*E. coli*), *Vibrio cholerae*, Enterococcus group ".

Table 4.1 The parameter of measurement in test water, control water and treated water

Parameter	Sampling Point		
	Test water	Control water (after 5 days)	Treated water (after 5 days)
Temperature	○	○	○
Salinity	○	○	○
pH	○	○	○
TSS	○	○	○
POC	○	○	○
DOC	○	○	○
10 ~ 50μm sized organisms	○	○	○
> 50μm sized organisms	○	○	○
Heterotrophic bacteria	○	○	○
Escherichia coli (*E. coli*)	○	○	○
Vibrio cholerae	○	○	○
Enterococcus group	○	○	○

■ **Test Waters for Chemicals Analysis**

Samples will be identified as a test, control, treated, and treated water after 3 or 5day storage.. Sampling items for chemical analysis are shown in Table 4.2. Samples will be identified clearly on chain of custody and sample bottles.

Table 4.2. The parameter of measurement in control water, and treated water

Test period	Sampling point							
	Day 0			Day 3		Day 5		
Parameter	Control water (SP3)	Untreated water (SP1)	Treated water (SP2)	Control water after 3 days storage (SP7)	Treated water 3 days storage (SP8)	Control water after 5 days storage (SP5)	Untreated water after 5 days storage (SP6)	Treated water after 5 days storage (SP4)
•OH	-	o	○	-	-	-	o	○
Bromide ion (Br^-)	○	○	○	○	○	○	○	○
Fluoride ion (F^-)	○	○	○	○	○	○	○	○
Bromate (BrO_3^-)	○	○	○	○	○	○	○	○
Nitrate (NO_3^-)	○	○	○	○	○	○	○	○
Sulfate (SO_4^{2-})	○	○	○	○	○	○	○	○
TOC	○	○	○	○	○	○	○	○
COD	○	○	○	○	○	○	○	○
TCE	○	○	○	○	○	○	○	○
PCE	○	○	○	○	○	○	○	○
$THMs^1$	○	○	○	○	○	○	○	○
$HAAs_5^2$	○	○	○	○	○	○	○	○
TOX	○	○	○	○	○	○	○	○
TRO	○	○	○	○	○	○	○	○
Hydrogen peroxide	○	○	○	○	○	○	○	○
Eco Toxicity Test	○		○	○	○	○		○

Superscripts

1 Chloroform, Dibromochloromethane, Bromodichloromethane, Bromoform
2 Monochloroacetic acid (MCAA), Dichloroacetic acid (DCAA), Trichloroacetic acid (TCAA), Bromochloroacetic acid (BCAA), Dibromoacetic acid (DBAA)

4.3 Sample Preservation

■ **Bio Efficacy Test**

Sample handling, preservation, and holding times will follow the method described in references in Table 4.3.

Table 4.3 Sample container, preservation, and maximum storage requirements for each parameter

Parameter	Container[1]	Preservation[2]	Maximum Holding Time[3]
Temperature	PE	NA	Analyze immediately
Salinity	PE	NA	Analyze immediately
pH	PE	NA	Analyze immediately
TSS	SB	Filter in refrigerator (-20℃)	Analyze as soon as possible[4]
POC	SB	Filter in refrigerator (-20℃)	Analyze as soon as possible
DOC	SB	Filtered water in refrigerator (-20℃)	Analyze as soon as possible
Phytoplankton (Organism 10-50 μm)	PE	NA	Analyze within 6 hours
Zooplankton (Organism > 50 μm)	PE	NA	Analyze within 6 hours
Herotrophic bacteria	SB	Fixation Formalin, 4℃	Analyze as soon as possible
Escherichia coli (*E. coli*)	SB	NA	Inoculate within 6 hours
Vibrio cholerae (serotypes O1 and O139)	SB	NA	Inoculate within 6 hours
Enterococcus group	SB	NA	Inoculate within 6 hours

Superscripts

1 Polyethylene (PE) or Sterile bottles (SB).
2 Sample preservation should be performed immediately upon collection.
3 Sample should be analyzed as soon as possible after collection. The times listed are maximum times that samples may be held before analysis and still be considered valid. The term "analyze immediately" usually means within 10 minutes or less of sample collection.
4 The term "As soon as possible" means that samples are analyzed within the maximum holding time specified in the EPA Standard Method (TSS) and JGOFS-Protocols (POC, DOC, Heterotrophic bacteria (DAPI)).

■ **Active Substances and Relevant Chemicals Analysis (Chemical Analysis)**

Sample handling, preservation, and holding times will follow those approved by EPA in 40 CFR Part 136 as described in Standard Methods for the Examination of Water and Wastewater, 21th Edition, 2005. Sample container, minimum sample volume, preservation, and maximum storage requirements for each parameter are summarized in Table 4.4 below.
The water samples should be directly taken full up in a sample bottles without air after washing by sample water. Bottles will be pre-cleaned and will not require rinsing with sample. When sample bottles are pre-preserved, the bottles should not be rinsed but be filled once with sample.

The collected samples will be cooled immediately in an ice-box to 4±2℃. In order to block off a light, the sample will be collected in a brown bottle and stored in a dark room. Temperature will be measured and recorded at the time of sample collection.

Transfer of samples will be accomplished using the laboratory's chain of custody form. The chain of custody form should contain the detailed information for transfer of sample, such as sample location, project name, and ID number, date and time of sample collection, any special notation on sample characteristics, initials of the person collecting the samples, date samples sent to the laboratory, and condition under which the samples were sent to the laboratory. The chain of custody will remain with the samples, sealed inside the cooler, until received by the laboratory.

Table 4.4 Sample container, preservation, and maximum holding time for each parameter

Parameter	Container[1]	Minimum Sample vol.	Preservation	Maximum Holing Time[3]
Bromide ion (Br^-)	P, G	1 L	Refrigerate[2]	28 days
Fluoride ion (F^-)	P	1 L	Refrigerate	28 days
Bromate (BrO_3^-)	P, G	1 L	Refrigerate	28 days
Nitrate (NO_3^-)	P, G	1 L	Analyze as soon as possible, refrigerate	48 hrs
Sulfate (SO_4^{2-})	P, G	1 L	Refrigerate	28 days
TOC	P, G	120 mL	Refrigerate, pH<2 H_3PO_4, Protect from oxygen	28 days
COD	P, G	1 L	Refrigerate, pH < 2 H_2SO_4	28 days
TCE	P, G	40 mL	Refrigerate, pH<2 (50% HCl 5-6 drops), a hermetic seal	14 days
PCE	P, G	40 mL	Refrigerate, pH<2 (50% HCl 5-6 drops), a hermetic seal	14 days
THMs	P, G	40 mL	Refrigerate, pH<2 (50% HCl 5-6 drops), a hermetic seal	14 days
$HAAs_5$	P, G	120 mL	Refrigerate, NH_4Cl (5 mg/50 mL), $Na_2S_2O_3$	14 days
TOX	P, G	1 L	Refrigerate, pH <2 H_2SO_4, a hermetic seal	28 days
TRO	P, G	10 mL	Not required	Analyze immediately
Hydrogen peroxide	P, G	100 mL	Refrigerate, 2 mL/50 mL fluorescence reagent[4]	7 days
*p*CBA	P.G	2 mL	Refrigerate	N.A
DMPO-OH adduct (•OH, Spin trap, ESR)	G	1 mL	Keep in a freezer and dark room, 100 mM DMPO	As soon as possible
Eco Toxicity Test	P	36L	Refrigerate	As soon as possible

Superscripts

1 Polyethylene (P), Glass (G) with TFE-lined screw-caps, preferably collect samples in a glass bottle. Polyethylene containers can also be used.

2 Refrigerate = storage at 4 ℃ in the dark

3 Sample should be analyzed as soon as possible after collection. The times listed are maximum times that samples may be held before analysis and still be considered valid. The term "Analyze immediately" usually means within 15 minutes or less of sample collection.

4 Fluorescence reagent: potassium hydrogen phthalate, 8,300 mg/L; p-hydroxyl phenyl acetic acid, 120 mg/L; Horseradish peroxidase,2 unit/mL; 1 N NaOH

4.4 Measures to void Cross-Contamination during Test Water Transfer and Sampling

All nets for the concentration of organisms in the test site should be strictly separated into three sets (each set uses 2 types of net; 7 μm mesh and 45 m mesh in diagonal dimension) to avoid cross-contamination. Three sets are defined as test water, control water and treated water. CTD, which measures temperature, salinity and dissolved oxygen, is rinsed three times with fresh water, and then is rinsed another three times with water which is going to be measured. A clean bench is installed in the barge ship to analyze heterotrophic bacteria, *Escherichia coli* (*E. coli*) and *Vibrio cholerae* (serotype O1 and O139). Blank samples are prepared for each microbe sample. Microbe samples are transported to the laboratory using a portable incubator and analyzed within 24 hours and 48 hours respectively.

4.5 Cleaning Method

■ **Bio Efficacy Test**

All sampling equipment and sample containers will be cleaned according to the equipment specifications or the analytical laboratory. All glassware and plastic ware will be cleaned in KORDI's (Korea Ocean Research & Development Institute) laboratory. KORDI will use the following procedure unless otherwise noted. Brand new plastic sampling containers, such as sterile bottles, are used to prevent possible contamination.

Table 4.5 Cleaning methods of apparatus using test

Phytoplankton (Organism 10-50μm)	When the water sample from each sampling point is obtained, polyethylene plastic container must be rinsed more than three times with water sample. Once used, the plastic container cannot be reused.
Zooplankton (Organism > 50 μm)	When the water sample from each sampling point is obtained, polyethylene plastic container must be rinsed more than three times with water sample. Once used, the plastic container cannot be reused.
DOC, POC	Soak glassware in 10% NaOH overnight at room-temperature. Drain, rinse three times with distilled water, three more times with 0.1N HCl and finally three times with distilled water. Oven dry overnight at 150℃. These are stored in plastic zipper bags until use.
Bacteria	Wash plastic and glassware with ULTRA CLEAN Laboratory Cleaner (DUKSAN PURE CHEMICAL CO., LTD.). Drain, rinse more than three times with distilled water. Oven dry overnight at 70℃ and then autoclave for sterilization. Plastic and glassware sterilized dry again at 70℃ until use.
TSS	Wash plastic and glassware with ULTRA CLEAN Laboratory Cleaner (DUKSAN PURE CHEMICAL CO., LTD.). Drain, rinse more than three times with distilled water. Oven dry overnight at 70℃ and then keep in plastic zipper bags until use.

Superscripts

Most sampling collection and analyses procedures will be performed by KORDI staff. Pre-treated procedures of equipments for determination of DOC and POC will follow the JGOFS - Protocol (JGOFS, 1994) [A1-3, A1-4].

■ Active Substances and Relevant Chemicals Analysis

All sampling equipment and sample containers will be cleaned according to the equipment specification or the analytical laboratory. All glassware and plastic ware will be cleaned in SGS Testing Korea Co.,Ltd. will use the following procedure unless otherwise noted.

1) Wash glassware and plastic ware with phosphate-free detergent and rinse with tap and distilled water.
2) Rinse well with 1:1 hydrochloric acid (HCl) or 1:1 nitric acid (HNO_3).
3) Rinse four times with distilled-deionized water.
4) Dry at 105℃ (400℃ for TOX) for 1 hr before use.

■ WET Test

Samples for WET testing will be taken from two land-based test cycles (one seawater test

cycle 1-2, and one brackish water test cycle 2-2). As it is the discharged ballast water immediately after treatment, at the middle, and the final ballast water discharge that is of concern in relation to any possible toxic effects, the WET testing of the PANASIA GloEn-Patrol™ Ballast System will be conducted with samples of discharge water immediately after treatment, at the three-day, and at the end of five-day period required in the land-based test for G8.

Collection and handling of field samples from the land-based (test barge) is undertaken by a joint team from the NeoEnBiz and DAU, using standard water sample collection methods and in accordance with the IMO Guidelines for Approval of Ballast Water Management Systems (G8 Guidelines), as adopted by Resolutions of the IMO Marine Environment Protection Committee (MEPC). Samples are collected in sterile disposable plastic bag(6L) and identified as control and treated test water. Collected sample bags are stored in cooler (ice box) and transported to test facility of NeoEnBiz by air plane within six hours of being collected.

When the samples are arrived to NeoEnBiz, laboratory personnel receive the samples, sign the form and enter the samples into the laboratory tracking system. The laboratory custodian will open the sample coolers and carefully check the contents for evidence of leakage and to verify that samples were kept on ice. The laboratory will then verify that all information on the sample container label is correct and consistent with the information of the chain-of-custody. Any discrepancy between the sample bottle and the information of the chain-of-custody, any leaking sample containers, or any other abnormal situation will be reported to the Quality Assurance Manager, who will in turn inform the Manager of PANASIA, and corrective actions will be discussed and implemented.

All WET testing will be performed at the same time immediately on delivering to test facility. For some tests which are necessary for the renewal of test solutions, samples were kept in dark and cold storage place during the given time of tests, in accordance with the laboratory sample custody. Laboratory sample custody will be performed in accordance with the laboratory's Study Plan for the specific tests being conducted, and will be consistent with the guidelines set forth in this section of the QAPP.

The laboratory has SOPs for sample custody including:

- Sample receipt and maintenance of custody;
- Sample storage;
- Sample tracking.

A SOP is defined as a written narrative step-wise description of laboratory operating procedures including examples of laboratory documentation. The SOPs must accurately describe the actual procedures used in the laboratory, and copies of the written SOPs shall be available to the appropriate laboratory personnel. These procedures are necessary to ensure that analytical data produced are acceptable for use. The laboratory SOPs provide mechanisms and documentation to meet the specification of the following sections.

5 TESTING PROTOCOLS

5.1 *In situ* Measurements

5.1.1 Temperature and Salinity

Temperature and salinity are measured using an Idronaut Ocean Seven 319 CTD. The equipment is calibrated once a year by the manufacturer.

5.1.2 Dissolved Oxygen (DO)

DO is measured using an Idronaut Ocean Seven 319 CTD. The DO meter attached to the CTD is calibrated each time prior to the measurement according to the guidance provided by manufacturer. Maintenance (mostly membrane and electrolyte replacement) should be carried out at least every three months.

5.1.3 pH

A pH meter is a model 1230, manufactured by Orion Research Inc. The equipment is calibrated using standard solutions (Orion application buffer, pH 4, 7, 10) each time prior to the measurement according to the guidance provided by manufacturer.

5.2 Discrete Samples

5.2.1 Organisms > 50 µm

Survivorship of the larger organisms 50 µm (mainly zooplankton) is determined based on the appendage's movement under a stereomicroscope (APHA-804C, 1985) [A1-2]. In each taxonomic group, individuals are classified as live or dead and counts of each group are recorded. Animals are designated as 'live' if they are actively moving or exhibited an escape behavior when probed with a fine needle. If no activity or movement of any kind is observed,

after the additional sticking with a fine needle, the animals are designated as 'dead'. And live or dead determination is confined to the unimpaired body of zooplankton. Abovementioned assessment method is also applied to the non-motile organisms larger than 50μm.

5.2.2 Organisms 10-50 μm

The disinfection efficacy of the ECS on 10~50μm sized organisms (mainly phytoplankton) is assessed by three kinds of measurements using photomicroscope, epifluorescence microscope and fluorometer (Turner Designs 10-AU).

With the use of the light microscope, the motility; for example of sliding or its own original movement assesses vitality of the phytoplankton.

Chlorophyll autofluorescence is used as an indicator of cell viability (Pouneva, 1997) [A1-15]. Intact chlorophyll of living cells shows red fluorescence, while dead or severely damaged chlorophyll lose the red fluorescence. Commonly, under a green filter using an epifluorescence microscope, the most living cells show brightly red color, while dead cells show faintly green color or disappearance of red fluorescence.

Fluorometer with high sensitivity can detect the fluorescence of phytoplankton more than one live cell per milliliter. Thus, if no value is read on the display of fluorometer, all cells are designated as 'dead', while if any number is read; there are live cells in the sample. Fluorometer is used as a supplementary means. Also, we will apply a method of fluorescein diacetate (FDA) staining to assess viability of 10~50μm sized organisms.

FDA stain : The FDA stock solution is prepared by mixing with regent grade dimethylsulfoxide (DMSO) at a concentration of 5 mg / ml following the instructions of Susana (2002) [A1-16]. FDA is commercially available from Sigma Co. This stock solution is stored in a refrigerator at 7°C (DMSO freezes at this temperature) and is thawed each day for the preparation of a working solution (Jochem, 1999) [A1-11]. A working stock solution is prepared by diluting the primary DMSO solution 100 times with chilled distilled water (50 μg / ml). The solution is mixed during preparation to

prevent the precipitation and kept cold in the dark. Each sample is stained by adding 100 µl of the working solution to 3 ml sample (end concentration: 1.7 µg ml^{-1} FDA). Stained samples are kept cool and dark for a minimum of 10 minutes prior to enumeration. Samples could be saved for up to 90 minutes without risking significant fluorescent degradation if kept in the dark and in an ice-bath.

Viability counts using FDA : The enumeration using epifluorescence microscopy to count FDA stained phytoplankton cells is modified based on Susana (2002) [A1-16]. The fraction of FDA-stained cells (viability) is determined under an epifluorescence microscope at 100× to 400× magnification, depending on cell size. Microplanktonic organism, which shows only green-fluorescence (wavelengths 520 to 530 nm) and does not emit red autofluorescence without a mobility, is counted under blue light excitation (wavelengths 450 to 500 nm) as viable organism, which is non-autotrophic, except where stated otherwise.

5.2.3 Heterotrophic Bacteria

For setting up the condition of influent water, 50mL seawater is fixed with neutralized formalin (final conc. 2~4%). One millilitre in well-fixed seawater is stained with 0.2mL DAPI (6-diamidino-2-phenylindole) working solution. After 5 minutes, at least 10 fields are counted under UV filter set of fluorescent microscopy at (× 1,000). (JGOFS, 1994) [A1-10]

5.2.4 *Escherichia coli* (*E. coli*)

A 10mL of sea water is filtered onto the 0.2µm membrane filter and then filters are placed on the top of *E. coli* Coliform and Coliform Count Plates (3M™ Petrifilm plate). The Petrifilm plates are incubated for 24 hrs at 35°C. The blue to red-blue colonies associates with entrapped gas in the Petrifilm EC plate (within approximately one colony diameter) is considered as *E. coli*. The enumeration of each sample is repeated eight to ten times. (3M Company, 2004) [A1-1]

5.2.5 *Enterococcus* Group

A 20~40 mL of sea water is filtered onto the 0.2μm membrane filter and then filters are placed on the Intestinal *Enterococci* agar plate. The pre-treated agar plates are incubated for 48 hrs at 35°C. The pink to brown colored CFU with a diameter of 0.5 to 2 mm is usually *Enterococcus* group. The enumeration of each sample is repeated eight to ten times. (Merk , 2002) [A1-13]

5.2.6 *Vibrio cholerae* (Serotypes O1 and O139)

5 to 10 mL of sea water is filtered onto the 0.2μm membrane filter and then filters are placed on the TCBS (Bisulfate Citrate Bile Sucrose) agar. Pre-treated TCBS agar plates are incubated for 24 hrs at 35°C. The green colored CFU is considered as *Vibrio parahaemolyticus*. The yellow colored CFU is isolated into nutrient agar and incubated for 24 hrs at 35°C. If the cultivated CFU has purple color, it is designated as positive, if not or partly purple, it is negative. When the incubated CFU is decided as positive, API20E test should be carried out. The possibility of *Vibrio cholerae* in the case of partly purple colored CFU is tested, but any CFU is not found in the API20E test. The enumeration of each sample is repeated eight to ten times. (Merk, 2003) [A1-14]

5.3 Chemical Measurements

5.3.1 Dissolved Organic Carbon (DOC)

For dissolved organic carbon (DOC) analysis, each seawater sample is filtered through a precombusted (450°C, 2hours) 25mm Whattman GF/F filters (nominal pore size 0.7μm) and 20 mL of filtered sample is collected in a precombusted 30-mL EPA vial (Wheaton, WH.W227354). After collection, the filtered seawater sample is immediately acidified with 10% H_3PO_4 solution and purged with ultrapure O_2 gas for 10 min to remove dissolved inorganic carbon (DIC). One hundred microliters of the DIC-free subsample is then injected into the combustion tube of a Shimadzu TOC-VCPH total organic carbon analyzer for the oxidation of DOC to CO_2, which is facilitated by a platinum catalyst at 650°C. The liberated CO_2 is subsequently measured using an infrared detector. On each day measurements are performed, a three-point calibration curve is constructed using potassium phthalate standards

freshly prepared in Milli-Q water. These standards cover a DOC concentration ranged of 0 to 10 mg/L and are run once per day. All DOC measurements report here represent the mean of three injections from each sample. (JGOFS, 1994) [A1-8]

5.3.2 Particulate Organic Carbon (POC)

For determination of particulate organic carbon (POC), samples are collected in 2 liter sterilization bottles. 200 mL of seawater sample is filtered onto precombusted (450°C, 2hours) 25mm Whattman GF/F filters (nominal pore size 0.7μm). During filtration, a slight vacuum (0.0027 MPa or 200 torr) is applied to avoid rupture of the cells on the filters. After filtration, the wet filters are dislodged from the filter holders and then stored frozen in a deep freezer (-20°C) until processed. Prior to analysis, the filters are placed overnight in a desiccator saturated with HCl fumes. The air in the desiccator is kept saturated by leaving concentrated HCl in an open container in the lower compartment of the desiccator. Thereafter, the filters are dried again at 65°C for two days. Immediately before analysis, with the use of a clean pair of tweezers, the dried filters are folded with tinfoil and palletized (Sharp, 1974). The CHN elemental analyzer (ThermoQuest, EA1112) is used to determine the concentration of POC on the dried filters. (JGOFS, 1994) [A1-9]

5.3.3 Total Suspended Solids (TSS)

Whattman GF/F filters (47mm, nominal pore size 0.7μm) are rinsed with 20 mL of distilled water three times and dry in the oven at 103 to 105°C for 1 hour and then cool to the room temperature for 30 minutes in the desiccator. The filters are then weighted. The sample volumes are chosen for the sufficient amount to yield residue between 10 mg and 200 mg after filtration. When there are very low total solids in samples (less than 10 mg/L), the deficiency of low weight is compensated by using a high-sensitive balance (0.001 mg). The appropriate amount of sample is filtered through the prepared 47mm Whattman GF/F filter and the residue retained on the filter is dried at 103 to 105°C for 1 hour. The filter is cooled in desiccator to room temperature for 30 minutes, and then re-weighted. The difference between pre and after weighted filter is divided by sample volume (unit liter) and represents the concentration of total suspended solid. (APHA, 1995) [A1-7]

5.4 Analysis of Active Substances, Relevant Chemicals and Other Chemicals

5.4.1 Relevant Chemical (OH Radical)

The •OH is regarded as a relevant chemical in GloEn-Patrol™ system. Due to the extremely short life-time (~milliseconds) and high reactivity of •OH, it is unable to monitor •OH directly in water with spectroscopic method (Buxton et al, 1988, IMO agenda item 4, 2007). The representative methods for the detecting and quantifying •OH are aromatic hydroxylation and the electron spin resonance spectroscopy (ESR) detection and •OH-probe method (Han et al., 2002, Elovitz and von Gunten, 1999).

.1 Detection using OH Radical Probe Compound (*p*CBA)

Commercially available *p*CBA (*para*-chlorobenzoic acid) is used as •OH probe. The concentration of *p*CBA remaining in the test sample is analyzed using high-performance liquid chromatograph (Gilson, France) equipped with a UV/Vis detector at 235 nm, an ODS2 C_{18} reverse phase column, and using methanol: 5 mM H_3PO_4 buffer solution as an eluent at a flow rate of 1 mL/min.

.2 Spin Trapping Method (ESR Spectroscopy)

•OH produced by GloEn-Patrol™ Ballast System in test water will be analyzed by a spin trapping method using an non-volatile nitrone trap 5,5-dimethyl-l-pyrroline-*N*-oxide (DMPO) with electron spin paramagnetic resonance (ESR), which is a direct •OH detection method. 1 mL of sample is taken the pyrex test tube and then 100 mM DMPO trap reagent is immediately injected into the test tube to form DMPO-OH adduct. 15 µL of the sample solution is collected by a quartz capillary tube and immediately placed in the EPR cavity to analyze for the DMPO-OH adduct. EPR measurements are conducted on a Bruker EMX spectrometer (BRUKER, Germany) operating at room temperature, microwave (frequency: 9.75 GHz, power 5 mW), 100 kHz field modulation frequency, 100 G of sweep width, 3465.0 G of center field, and 2.56 ms of time constant. Hydrogen peroxide (H_2O_2) and Ferric sulfate ($FeSO_4$) are used to confirm detection of DMPO-OH adduct as a reference compounds. The spin adduct yield is calculated by double integral of the spectrum of the stable radical diphenyl-2-picrylhydrazyl (DPPH).

The minimum concentration of •OH that can be quantitatively detected by the ESR method is 5×10^{-8} M.

5.4.2 Other Chemicals

.1 Inorganic Anions

The inorganic anions (Br^-, F^-, SO_4^{2-}, NO_3^-, and BrO_3^-) in test water will be analyzed in accordance with test procedure described in USEPA 300.0. Each seawater sample is filtered with Ag cartridge (OnGardII-Ag, Dionex) and pre-washed 0.45 μm membrane to eliminate high concentration chloride ion and particles. The concentration of anions will be analyzed with Ion Chromatograph (IC) equipped with analytical columns (Dionex AG18-HC/AS18-HC, 4 mm) and suppressed conductivity detector. Table 5.1. summarize the recommended operating conditions for the ion chromatograph.

Table 5.1 Chromatographic Conditions for the Inorganic common Anions

Ion Chromatograph	Dionex ICS2000
Columns	Dionex AG18-HC/AS18-HC, 4 mm
Detector	Suppressed Conductivity Detector
Suppressor	RFIC, 80 mA
Eluent	32 mM KOH
Eluent Flow	1.00 ml/min
Sample Loop	200 μl
System Backpressure	2000 psi
Recommended method total analysis time	15 min

.2 Total Organic Carbon (TOC)

The TOC (Total Organic Carbon) will be pretreated and analyzed by the procedure based on the USEPA method 415.1. For Total organic carbon (TOC) analysis, each seawater sample collected *in situ* is immediately acidified with 10% H_3PO_4 solution. 25 mL of the test sample is then injected into the combustion tube of a Shimadzu TOC-5000A total organic carbon analyzer for the oxidation of

TOC to CO_2, which is facilitated by a platinum catalyst at 680°C. The liberated CO_2 is subsequently measured using an infrared detector.

.3 Total Organic Halides (TOX)

TOX (total organic halides) will be measured by the procedure based on the USEPA method 9020. Two adsorption columns (Pyrex, 5 cm × 6 mm × 2 mm) each containing 40 mg of 100/200-mesh activated carbon are connected in series. 100 mL of sample is collected in sample reservoir and filtered through the activated-carbon columns at a rate of approximately 3 mL/min. The columns-in-series is then washed with 2 mL of the 5,000 mg/L of nitrate solution at a rate of approximately 2 mL/min to displace inorganic chloride ions. After being rinsed with nitrate solution, the columns should be protected from the atmosphere and other contaminants until used. The contents of each column are pyrolyzed separately. The volatile components are pyrolyzed in a CO_2-rich atmosphere at a low temperature to ensure the conversion of brominated trihalomethanes (THMs) to a titratable species. The less volatile components are then pyrolyzed at a high temperature in an O_2-rich atmosphere. Then, the contents of each column are transferred to the quartz pyrolysis tube for individual analysis. The pyrolysis tube is placed in the 200℃zone for 2 min and then 800℃zone for 6-10 min, respectively. The effluent gases from the pyrolysis furnace are directly analyzed in the micro-coulometric-titration cell.

.4 Chemical Oxygen Demand (COD)

COD (chemical oxygen demand) will be measured by the procedure based on the USEPA method 410.4 (Hach method 8000). For analysis of COD, the sample is pre-treated by digestion procedure. COD reactor (model, Hach) is pre-heated at 150℃. 2 mL of sample is carefully added to HACH stock COD digestion reagent vial. The vial's cap is tightened to avoid vapor loss or accidental spillage and placed in the COD reactor for 2 hrs at 150℃. After 2 hrs, the vials is taken out from the COD reactor and inverted once to mix and cooled. The spectrophotometer (DR-2500, Hach) is set to read at 420 nm (Hach program 430) and zeroed with the blank. The cleaned, capped, cooled Hach tube is placed into

the COD tube cell holder with the Hach logo facing forward. The absorbance of the sample is measured and recorded. The concentration of sample is calculated from the established calibration curve, which are prepared at 0, 50, 100, and 150 mg/L by the same manner as the sample.

.5 TCE and PCE

TCE (Trichloroethylene) and PCE (Tetrachloroethylene) will be measured by the procedure based on the USEPA method 8260 using GC/MS (gas chromatograph/mass spectrometer). The 40 mL of seawater sample is pretreated with the purge and trap method using ARCHON system which is composed of the auto-sampler and sample concentrator (TEKMAR 3000). The ARCHON system automatically adds 50 μg/mL of surrogate (toluene-d_8, 4-bromofluorobenzene (BFB), 1,2-dichloroethene-d_4, and dibromofluoromethane) and internal standard (fluorobenzene, chlorobenzene-d_5, 1,4-dichlorobenzene-d_4) into all samples, before the aliquot of sample is purged. The ARCHON program and temperatures should already be set as in Table 5.2-5.3. The pretreated sample is separated and detected by GC/MS (Agilent 6890N/5973i). The operating condition of GC/MS for TCE and PCE analysis is summarized in Table 5.4. After analysis, check the pH of the remaining sample with wide range pH kit. Sample pH must be less than 2. The concentration of sample is calculated from the established calibration curve, which is ranging from the detection limit to approximately 50 times the detection limit and prepared by the same manner as the sample.

Table 5.2 ARCHON program and operating condition

1st Vial: __	W. Stir Time: 0.0
Last Vial: __	W. Settle Time: 0.0
Sample Volume: 5 ~ 20	Syringe Flush: 01
Dilution Factor: No	Desorb Time: 1.0
Rinse Volume: 8 ~ 22	Oper Mode Remote
Rinses: 01	Cycle Timer: 0.0
STD (1): Yes or No	Aux Timer: 0.0
STD (2): Yes or No	Link to Method:__
Stir: No	
Purge Gas Pressure: 20 psi	

Table 5.3 TEKMAR 3000 conditions (Method 14)

Line Temp(°C): 150	Valve Temp(°C): 150	Purge Ready Temp(°C): 30
Purge Temp(°C): 30	Mount Temp(°C): 40	MCS Line Temp(°C): 150
Sample Heater: Off	Sample Temp(°C): 40	Purge Time: 11:00 min
Dry Purge Time: 1:00 min	GC Start: Start of Desorb	Cryo Focuser: Off
Desorb Preheat(°C): 250	Desorb Time: 4:00 min	Desorb Temp(°C): 255
Sample Drain: On	Bake Time: 10:00 min	Bake Temp(°C): 260
MCS Bake Temp(°C): 300	Type: AQUATek 50	
Trap Pressure Control: 4 psi	System Pressure Control: 20 psi	

Table 5.4 GC/MS condition

GC/MS	Agilent 6890N/5973i
Capillary column	DB-VRX (60m×0.25mm×1.4um)
Electron energy	70 eV
Mass range	35-300
Scan time	2 scans/sec
Initial oven temperature (°C)	40
Temperature programming	10 °C/min
Final oven temperature (°C)	220
Injector temperature (°C)	200
MS Source temperature (°C)	230
MS Quadrupole temperature (°C)	150
Initial Pressure	35.5 psi
Split flow	75 mL/min
Carrier gas	Helium
Carrier flow	2.5 mL/min (constant flow)

.6 Trihalomethanes (THMs)

Trihalomethanes (THMs) will be measured by the procedure based on the USEPA method 524.2 using GC/MS (Agilent 6890N/5973i). The seawater sample is concentrated using the closed system auto-sampler (ARCHON) and the purge and sample concentrator module (TEMAR 3100). The purge gas (helium) flow is adjusted in the ARCHON auto-sampler to 40 mL/min. For the closed system auto-sampler, the 40-mL sample vial is place directly into the 40-sample auto-sampler tray. The auto-sampler automatically adds 20 mLs of sample to the purge vessel located on the sample concentrator for analysis. The TEKMAR 3100 liquid sample concentrator parameters are shown in Table 5.5. The concentrated aliquot is separated and detected by GC/MS (Agilent 6890N/5973i). The operating condition of GC/MS for THMs analysis is shown in Table 5.6. Data is collected and compounds are tentatively identified using the acquisition software. The concentration of sample is calculated from the established calibration curve, which is usually ranging from 0.0005 mg/L to 0.020 mg/L depending on the analyte concentration.

Table 5.5 TEKMAR 3100 conditions

Purge Time	11 min
Dry purge Time	2.0 min
Desorb. Pre-heat Temp.	245°C
Desorb. Time	2.0 min
Desorb. Temp.	250°C
Transfer line Temp.	120°C
Bake Temp.	260°C
Valve Temp.	120°C

Table 5.6 GC/MS condition

GC/MS	Agilent 6890N/5973i
Capillary column	DB-VRX (60m×0.25mm×1.4um)
Electron energy	70 eV
Mass range	35-260
Scan time	2 scans/sec
Initial oven temperature (°C)	40
Temperature programming	10 °C/min
Final oven temperature (°C)	220
Injector temperature (°C)	200
MS Source temperature (°C)	230
MS Quadrupole temperature (°C)	150
Initial Pressure	35.5 psi
Split flow	75 mL/min
Carrier gas	Helium
Carrier flow	2.5 mL/min (constant flow)

.7 Haloacetic Acids ($HAAs_5$)

Haloacetic acids ($HAAs_5$) will be measured by the procedure based on the USEPA method 552.2 using GC/MS (Agilent 6890N/5973i). For pretreatment of seawater sample, the sample is extracted using methyl-*tert*-butyl ether (MTBE, high purity) and is followed by the derivatization of acidic methanol using the USEPA 552.2 method. After extracting and derivertizing the sample, 1.0 mL of the upper MTBE layer is transferred to an auto-sampler vial with screw or crimp cap and a teflon-faced seal. 10 μL of internal standard (25 μg/mL 1,2,3-trichloropropane in MTBE) is then added to the vial to be analyzed. 2 μL of the sample extract is injected into GC/MS. The operating conditions of GC/MS for $HAAs_5$ analysis are summarized in Table 5.7. The resulting peak sizes in area or height units are automatically recorded with the linked computer program. The concentration of sample is calculated from the established calibration curve, which is ranging from

the detection limit to approximately 50 times the detection limit and prepared by the same manner as the sample. The sample extract should be analyzed as soon as possible. If kept, the extract may be stored up to seven days at 4 °C or less or up to 14 days at -10 °C or less. The extract should be kept away from light in amber glass vials with Teflon-lined caps.

Tabel 5.7 GC/MS operating condition for $HAAs_5$ analysis

GC/MS	Agilent 6890N/5973i
Capillary column	DB-5, DB-625 (fused silica capillary (5 % phenyl)-methylpolysiloxane, 30 m x 0.32 mm x 0.25 µm)
Electron energy	70 eV
Mass range	35-300
Scan time	2 scans/sec
Initial oven temperature (^oC)	40
Temperature programming	Hold at 35 °C for 10 minutes, ramp to 75 °C at 5 °C/min. and hold 15 minutes, ramp to 100 °C at 5 °C/min. and hold five minutes, ramp to 135 °C at 5 °C/min. and hold two minutes.
Final oven temperature (^oC)	135
Injector temperature (^oC)	200
MS detector temperature (^oC)	260
Split/splitless mode	Splitless injection with 30 seconds delay
Carrier gas	N_2

.8 Total Residual Oxidants (TRO)

TRO (Total residual oxidants) present in seawater sample will be directly measured *in situ* by the DPD (*N,N*-diethyl-p-phenylenediamine) colorimetric method based on USEPA 330.5 (Hach method 8167). To remove any particles in sample, seawater sample is filtered with 0.45 µm membrane filter which is pre-washed with distilled water. 10 mL of filtered sample and the blank are filled two

sample cells with cap (Cat.No. 21228-00, Hach). The contents of one DPD Total chlorine powder pillow (Cat No. 21056-69, Hach) are added into the sample cells. The sample cells are then swirled to mix for 20 seconds and hold on the sample rack for 3 minutes. After 3 minutes, the sample cell is placed into the cell holder in spectrophotometer (DR-2500, Hach) which is zeroed with the blank. The absorbance of seawater sample is measured and the data is recorded in the mg/L Cl_2.

.9 Hydrogen Peroxide (H_2O_2)

The analytical method for hydrogen peroxide is based on the fluoromatric method (Lazrus et al., 1985, Oh et al., 2005). The fluoromatric method uses the reaction of p-hydroxyphenylacetic acid and hydrogen peroxide in the presence of horseradish type IV peroxidase enzyme, forming the dimmer analyzed with fluorescence detector (SOMA, Japan) in the conditions of excitation at 320 nm and emission at 420 nm. This system is composed of the DC control motor pump (Cole Parmer, USA) for the injection of reagents and sample, the solenoid valves for the control of the mixture order of reagents and sample, and the fluorescence detector. This system can be electrically controlled and data signals are converted into the real hydrogen peroxide concentration unit (μg/L) with calibration curve (10, 50, 100, 200, and 500 μg/L) and acquired by computer system including the interface card (Labview, USA). Hydrogen peroxide can be measured at low level (10 μg /L) with this instrument.

5.5 Toxicity Testing of Treated Ballast Water

This study aims to assess the residual toxicity of whole-effluent ballast water after treatment by the PANASIA GloEn-Patrol™ Ballast System, in accordance with the IMO G9 Procedure. The objectives are to analyze the impact of treated ballast water on ecosystems of seawater and of brackish water, to evaluate possible risks to humans and other receptors, posed by current and future exposure to ballast water treated by the PANASIA GloEn-Patrol™ Ballast System, and to determine what additional measures might be needed to reduce any risks.

Aquatic toxicity testing of the whole-effluent from the GloEn-Patrol™ Ballast System of PANASIA in accordance with the IMO G9 Procedure requires a number of tests to be carried out, as follows:

- Acute Toxicity Test with the Rotifer, *Brachionus*
- Growth Inhibition Test with Microalgae
- Survival Toxicity Test with Larval Fish
- Reproduction (or population growth) Toxicity Test with Rotifer
- Growth Toxicity Test with Larval Fish
- Sediment Toxicity Test with Amphipod

■ **Aquatic Toxicity Test 1: Acute Toxicity Test with the Rotifer, *Brachionus***

- Twenty-four hour survival test with marine rotifer, *Brachionus plicatilis* leads to an estimation of acute toxicity, including the concentration expected to kill 50% of the test rotifers (LC50) in 24 h.
- The assay will be performed in basic accordance with "ASTM E1440 Standard Guide for Acute Toxicity Test with the Rotifer, *Brachionus*."
- Test condition in acute toxicity test with the rotifer, *Brachionus plicatilis*

Tabel 5.8 Acute Toxicity Test with the Rotifer, *Brachionus*

Parameter		Conditions
Test species		*Brachionus plicatilis* (<24hrs neonate)
Test substances	Control seawater	SP3-S0, SP7-S3, SP5-S5
	Control brackish water	SP3-B0, SP7-B3, SP5-B5
	Treated ballast seawater	SP2-S0, SP8-S3, SP4-S5
	Treated ballast brackish water	SP2-B0, SP8-B3, SP4-B5
Test control substance		Natural seawater
Sampling time		Day 0, Day 3, Day 5
Egg hatching	Period	Hatching for 22-24 hrs
	Culture media	Filtered natural seawater (FNS)
	Culture condition	25℃, 1,000-3,000 lux
Test system		Static non-renewal
Incubation facility		Incubator (Darkness)
Age of test organisms		Newly hatched neonate (0 to 2 hrs old)
Duration of the test		24 hrs
Test vessel	Material	Polystylene
	Size	48-well plate
	Fill volume	1 ml/well
Detail of growth medium (for test duration)	Name	Test substances (treated ballast water, control (untreated) water)

	pH	seawater	pH7.8 - pH8.3
		brackish water	pH7.8 - pH8.3
	Salinity	seawater	32‰ ~ 34‰
		brackish water	19‰ – 22‰
Dilution water	Source	Natural seawater	
	Type	Filtered natural seawater	
	pH	pH 7.9 ~ pH 8.1	
	Salinity	32 ~ 34‰	
Aeration or agitation		None	
Number of larvae/chamber		5	
Number of replicate	Control water (seawater or brackish water)	6	
	Treated ballast water (seawater or brackish water)	6	
Test concentrations	Control water	1 (100%)	
	Treated ballast water	3 (25, 50, 100%), control (0%)	
Vehicle (type, percentage, if used)		Natural sweater 100%	
Test conditions	Temperature	25℃	
	Illuminance	1,000-3,000 lux	
	Photoperiod (Light : Dark)	0 hrs : 24hrs	
	Light intensity and quality	cool-white fluorescent lights	
Test solution volume		1 mL/replicate	
Renewal of test solutions		None	
Endpoints		Survival	
Test acceptability		Minimum mean control survival of 90 %	

■ Aquatic Toxicity Test 2: Growth Inhibition Test with Microalgae

- Ninety-six hour growth inhibition test with marine algae, *Dunaliella tertiolecta* and *Skeletonema costatum* or *Phaeodactylum tricornutum* provides information on the acute or chronic toxicity of test materials to an important component of the aquatic biota and might indicate whether additional testing is desirable.
- The assay will be performed in basic accordance with "ASTM E1218-97a Standard Guide for Conducting Static 96-h Toxicity Tests with Microalgae."
- Test condition in the microalgae growth inhibition of *Dunaliella tertiolecta* and *Skeletonema costatum* or *Phaeodactylum tricornutum*

Tabel 5.9 Growth Inhibition Test with Microalgae

Parameter		Conditions	
Test species		*Skeletonema costatum* or *Phaeodactylum tricornutum*	*Dunaliella tertiolecta*
Test substances	Control seawater	SP3-S0, SP7-S3, SP5-S5	
	Control brackish water	SP3-B0, SP7-B3, SP5-B5	
	Treated ballast seawater	SP2-S0, SP8-S3, SP4-S5	
	Treated ballast brackish water	SP2-B0, SP8-B3, SP4-B5	
Test control substance		Natural seawater	
Sampling time		Day 0, Day 3, Day 5	
Preincubation	Period	4-7 days	4-7 days
	Culture media	f/2media in filtered natural seawater (FNS)	f/2media in filtered natural seawater (FNS)
	Culture condition	20℃	20℃
Test system		Static non-renewal	Static non-renewal
Incubation facility		Shaking Incubator	Shaking Incubator
Duration of the test		96 hrs	96 hrs
Test vessel	Material	25T flask (Polystylene)	25T flask (Polystylene)
	Size	50 mL	50 mL
	Fill volume .	30 mL	30 mL
Detail of growth medium	Name	Test substances with f/2medium	Test substances with f/2medium

(for test duration)	pH	seawater	pH7.8 - pH8.3	pH7.8 - pH8.3
		brackish water	pH 7.8 ~ pH 8.3	pH 7.8 ~ pH 8.3
	Salinity	seawater	32‰ – 34‰	32‰ – 34‰
		brackish water	19‰ ~ 22‰	19‰ ~ 22‰
Dilution water	Source		Natural seawater	Natural seawater
	Type		Filtered natural seawater	Filtered natural seawater
	Initial pH		pH 7.9 - pH 8.1	pH 7.9 - pH 8.1
	Salinity		32 - 34‰	32 - 34‰
Aeration or agitation			None	None
Initial cell density (cells/mL)			10,000 – 20,000	10,000 – 20,000
Test concentrations	Control water (seawater or brackish water)		1 (100%)	1 (100%)
	Treated ballast water (seawater or brackish water)		3 (25, 50, 100%), control (0%)	3 (25, 50, 100%), control (0%)
Number of replicate	Control water		3 or 5	3 or 5
	Treated ballast water		3 or 5	3 or 5
Vehicle (type, percentage, if used)			Natural sweater 100%	
Test conditions	Temperature		20℃	20℃
	Illuminance		4,300 lm/m2	4,300 lm/m2
	Photoperiod (Light : Dark)		16 hrs : 8 hrs	16 hrs : 8 hrs
	Light intensity and quality		Cool-white fluorescent lights	
	Shaking		180 rpm	180 rpm
Test solution volume			30 mL/replicate	
Renewal of test solutions			None	
Endpoints			Cell growth	
Test acceptability			Cell counts in the controls should increase by a factor of at least 16 during the test	

■ **Aquatic Toxicity Test 3 : Survival Toxicity Test with the Fish, *Cyprinodon variegates* (larvae)**

- Sheepshead minnow, *Cyprinodon variegatus*, larvae (preferably less than 24 hrs old) are exposed in a non-static renewal system for 96 hrs to different concentrations of effluent or to receiving water, to assess acute toxicity. Test results are based on the survival of the larvae.
- The assay will be performed in basic accordance with "USEPA 821/R-02/014 Standard Guide for Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Marine and Estuarine Organisms."
- Test condition in survival toxicity test with sheepshead minnow, *Cyprinodon variegates* (larvae).

Tabel 5.10 Survival Toxicity Test with the fish, *Cyprinodon variegates* (larvae)

Parameter		Conditions
Test species		*Cyprinodon variegatus* (Larvae)
Test substance	Control seawater	SP3-S0, SP7-S3, SP5-S5
	Control brackish water	SP3-B0, SP7-B3, SP5-B5
	Treated ballast seawater	SP2-S0, SP8-S3, SP4-S5
	Treated ballast brackish water	SP2-B0, SP8-B3, SP4-B5
Test control substance		Natural seawater
Sampling time		Day 0, Day 3, Day 5
Acclimation	Period	Continuous maintaining
	Culture media	Natural seawater
	Culture condition	25 ± 2 ◦C, BOD 110%
Test system		Static non renewal
Incubation facility		Incubator
Age of test organisms		Newly hatched larvae (less than or equal to 24 hrs old)
Feeding		None
Duration of the test		96 hrs (4 days)
Test vessel	Material	Glass
	Size	1 L glass beaker
	Fill volume	1L

Detail of growth medium (for test duration)	Name	Test substances (treated ballast water, control water)	
	pH	seawater	pH7.8 - pH8.3
		brackish water	pH7.8 - pH8.3
	Salinity	seawater	32‰ – 34‰
		brackish water	19‰ ~ 22‰
Dilution water	Source	Natural seawater	
	Type	Filtered natural seawater	
	pH	pH7.9 - pH8.1	
	Salinity	32‰ – 34‰	
Aeration or agitation		None	
Number of larvae/chamber		10 per test chamber	
Number of replicate	Control water (seawater or brackish water)	3	
	Treated ballast water (seawater or brackish water)	3	
Test concentrations	Control water	1 (100%)	
	Treated ballast water	3 (25, 50, 100%), control (0%)	
Vehicle (type, percentage, if used)		Natural sweater 100%	
Test conditions	Temperature	20±1°C	
	Illuminance	Ambient laboratory levels (10-20 μE/m2/s (50-100 ft-c))	
	Photoperiod (Light : Dark)	16 hrs : 8 hrs	
	Light intensity and quality	Cool-white fluorescent lights	
Test solution volume		500 mL/replicate	
Renewal of test solutions		None	
Endpoints		Survival	
Test acceptability		Minimum mean control survival of 80% or greater survival in controls	

■ **Aquatic Toxicity Test 4: Reproduction (or population growth) Toxicity Test with Marine Rotifer, *Brachionus plicatilis***

- A four day reproduction (population growth) test with marine rotifer, *Brachionus plicatilis* to assess chronic toxicity.
- The assay will be performed in basic accordance with "Cyst-based toxicity tests (Janssen et al., 1994) Standard Guide for Short-chronic toxicity tests with the freshwater rotifer, *Brachionus calyciflorus*."
- Test condition in reproduction (or population growth) toxicity test of *Brachionus plicatilis*

Tabel 5.11 Survival Reproduction (or population growth) Toxicity Test with marine rotifer, *Brachionus plicatilis*

Parameter		**Conditions**
Test species		*Brachionus plicatilis* (<24hrs neonate)
Test substances	Control seawater	SP3-S0, SP7-S3, SP5-S5
	Control brackish water	SP3-B0, SP7-B3, SP5-B5
	Treated ballast seawater	SP2-S0, SP8-S3, SP4-S5
	Treated ballast brackish water	SP2-B0, SP8-B3, SP4-B5
Test control substance		Natural seawater
Sampling time		Day 0, Day 3, Day 5
Egg hatching	Period	Hatching for 22-24 hrs
	Culture media	Filtered natural seawater (FNS)
	Culture condition	25℃, 1,000-3,000 lux
Test system		Static non-renewal
Incubation facility		Incubator (Darkness)
Age of test organisms		Newly hatched neonate (0 to 2 hrs old)
Feeding		Supply 106 cells of *Nannochloropsis oculata* per test well at the start of test
. Duration of the test		. 96 hrs
Test vessel	Material	Polystylene

	Size	48-well plate	
	Fill volume	1 ml/well	
Detail of growth medium (for test duration)	Name	Test substances (treated ballast water, control water)	
	pH	seawater	pH7.8 - pH8.3
		brackish water	pH 7.8 - pH 8.3
	Salinity	seawater	32‰ – 34‰
		brackish water	19‰ - 22‰
Dilution water	Source	Natural seawater	
	Type	Filtered natural seawater (FNS)	
	pH	pH 7.9 - pH 8.1	
	Salinity	32‰ - 34‰	
Aeration or agitation		None	
Number of larvae/chamber		5 per test chamber	
Number of replicate	Control water (seawater or brackish water)	6	
	Treated ballast water (seawater or brackish water)	6	
Test concentrations	Control water	1 (100%)	
	Treated ballast water	3 (25, 50, 100%), control (0%)	
Solvent (type, percentage, if used)		Natural sweater 100%	
Test conditions	Temperature	25℃	
	Illuminance	1,000-3,000 Lux	
	Photoperiod (Light : Dark)	0 hrs : 24 hrs	
	Light intensity and quality	Cool-white fluorescent lights	
Test solution volume		1 mL/replicate	
Renewal of test solutions		None	
Endpoints		Reproduction (Population growth)	
Test acceptability		Minimum mean control survival of 80 %	

■ **Aquatic Toxicity Test 5: Growth Toxicity Test with Marine Fish, *Cyprinodon varietagus*.**

- Seven days larval growth test with marine fish, *Cyprinodon varietaus* to assess short chronic toxicity.
- The assay will be performed in basic accordance with "USEPA 821/R-02/014 Standard Guide for Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Marine and Estuarine Organisms."
- Test condition in population growth toxicity test of *sheepshead minnow*, *Cyprinodon variegates*

Tabel 5.12 Growth Toxicity Test with marine fish, Cyprinodon varietagus

Parameter		Conditions
Test species		*Cyprinodon variegatus* (Larvae)
Test substance	Control seawater	SP3-S0, SP7-S3, SP5-S5
	Control brackish water	SP3-B0, SP7-B3, SP5-B5
	Treated ballast seawater	SP2-S0, SP8-S3, SP4-S5
	Treated ballast brackish water	SP2-B0, SP8-B3, SP4-B5
Test control substance		Natural seawater
Sampling time		Day 0, Day 3, Day 5
Acclimation	Period	Continuous maintaining
	Culture media	Natural seawater
	Culture condition	25 ± 2 °C, BOD 110%
Test system		Static renewal
Incubation facility		Incubator
Age of test organisms		Newly hatched larvae (less than or equal to 24 hrs old)
Feeding		Newly hatched *Artemia* nauplii Feed once a day 0.10 g wet weight *Artemia* nauplii per replicate on Days 0-2; Feed 0.15 g wet weight *Artemia* nauplii per replicate on Days 3-6
Duration of the test		7 days
Test vessel	Material	Glass
	Size	1 L glass beaker
	Fill volume	1L
Detail of growth medium	Name	Test substances (treated ballast water, control water)

(for test duration)	pH	seawater	pH7.8 - pH8.3
		brackish water	pH 7.8 - pH 8.3
	Salinity	seawater	32‰ - 34‰
		brackish water	19‰ - 22‰
Dilution water	Source	Natural seawater	
	Type	Filtered natural seawater	
	pH	pH7.9 - pH8.1	
	Salinity	32‰ - 34‰	
Aeration or agitation		None	
Number of larvae/chamber		10 per test chamber	
Number of replicate	Control water (seawater or brackish water)	3	
	Treated ballast water (seawater or brackish water)	3	
Test concentrations	Control water	1 (100%)	
	Treated ballast water	3 (25, 50, 100%), control (0%)	
Solvent (type, percentage, if used)		Natural sweater 100%	
Test conditions	Temperature	20±1℃	
	Illuminance	Ambient laboratory levels (10-20 μE/m2/s (50-100 ft-c))	
	Photoperiod (Light : Dark)	16 hrs : 8 hrs	
	Light intensity and quality	Cool-white fluorescent lights	
Test solution volume		500 mL/replicate	
Renewal of test solutions		Daily	
Endpoints		Growth rate	
Test acceptability		The tests are acceptable if the average survival of control larvae equals or exceeds 80%.	

■ **Aquatic Toxicity Test 6: Sediment Toxicity Test with Marine Amphipod, *Monocorophium acherusicum***

- Ten days sediment toxicity test with marine amphipod, *Monocorophium acherusicum* is to determine whether contaminants in sediment are harmful to or are bioaccumulated by benthic organisms. The tests can be used to measure interactive toxic effects of complex contaminant mixtures in sediment.
- The assay will be performed in basic accordance with "USEPA 600/R-94/025 Standard Guide for Short-term Methods for Assessing the Toxicity of Sediment-associated Contaminants with Estuarine and Marine Amphipods."
- Test condition in sediment toxicity test of *Monocorophium acherusicum*.

Table 5.13 Sediment toxicity test with marine amphipod, *Monocorophium acherusicum*

Parameter		Conditions
Test species		*Monocorophium acherusicum*
Test substance (Overlying water)	Control seawater	SP3-S0, SP7-S3, SP5-S5
	Control brackish water	SP3-B0, SP7-B3, SP5-B5
	Treated ballast seawater	SP2-S0, SP8-S3, SP4-S5
	Treated ballast brackish water	SP2-B0, SP8-B3, SP4-B5
Test control substance		Natural seawater
Sampling time		Day 0, Day 3, Day 5
Acclimation	Period	Continuous maintaining
	Culture media	0.1 μm filtered natural seawater (FNS)
	Culture condition	20℃ ± 1
Test system		Whole sediment toxicity test, static
Incubation facility	Aging	Stirrer
	Incubation for test duration	Incubator
Size and life stage of amphipods		350 ~ 500 μm (mesh size) amphipods
Feeding		None
Aging between sediment and test substances		7 days
Test duration (sediment interaction)		10 days
Test vessel	Material	Glass
	Size	1 L glass beaker
	Fill volume	1L

Detail of growth medium (for test duration)	Name	Test substances (treated ballast water, control water)	
	pH	seawater	pH7.8 - pH8.3
		brackish water	pH 7.9 ~ pH 8.3
	Salinity	seawater	32‰ – 34‰
		brackish water	19‰ ~ 22‰
Dilution water	Source	Natural seawater	
	Type	Filtered natural seawater	
	pH	pH7.9 - pH8.1	
	Salinity	32‰ – 34‰	
Aeration or agitation		None	
Number of larvae/chamber		10 per test chamber	
Number of replicate	Control water (seawater or brackish water)	4	
	Treated ballast water (seawater or brackish water)	4	
Test concentrations	Control water	1 (100%)	
	Treated ballast water	3 (25, 50, 100%), control (0%)	
Vehicle (type, percentage, if used)		Natural sweater 100%	
Test conditions	Temperature	20±1°C	
	Illuminance	500 - 1,000 lux	
	Photoperiod (Light : Dark)	24 hrs : 0 hrs	
	Light intensity and quality	Cool-white fluorescent lights	
Sediment volume (wet weight)		200 g /replica	
Overlying water volume		800 mL /replica	
Overlying water	Aging duration (7 days)	Test substances (treated ballast water, control water)	
	Test duration (10 days)	Filtered natural seawater (FNS)	
Renewal of overlying water		None	
Endpoints		Survival	
Test acceptability		Minimum mean control survival of 90 %	

The Study Plans for each of these tests identify the major tasks involved in the study, together with sub-tasks required for the completion of each major task. The Study Plan defines the methodology to be employed by the project staff in satisfying the defined objectives of the study and describes the monitoring program to collect new data for this project, including identifying measurements and analyses to be conducted, number of samples to be collected,

and equipment requirements. The Study Plans also identify specific work products, including deliverable items such as reports. This QAPP addresses monitoring activities defined in the study plans.

The Study Plans contain project schedules that identify the approximate start time, duration and the approximate end time of each task. The schedules will be updated as necessary and will be used by the Project Manager to review overall progress on the project.

6 QUALITY CHECK

6.1 Bio Efficacy Test

6.1.1 Representativeness

KORDI appointed the quality representative who irrespective of other duties and responsibility and authority for ensuring that the quality system is implemented and followed at all times.

Quality representative continue the check of accuracy and precision for these tests, especially the tests conducted in KORDI.

6.1.2 Accuracy

Accuracy is a measure of confidence that describes how close a measurement is to its "true" value.

KORDI ensures field accuracy by field instrument calibration according to the manufacturer's instructions and by using standards and chemicals that are current (prior to expiration date), and by following proper sampling, sample handling and field analysis protocols.

Laboratory accuracy is normally determined by the percent recovery of the target analyte in spiked samples and also by the recoveries of the surrogates in all samples and QC (Quality Control) samples. Accuracy is calculated as follows:

$$\%R = \frac{Analyzed\ value}{true\ value} \times 100$$

KORDI will ensure its own laboratory accuracy by meeting %R values as shown in Table 6.1 below.

6.1.3 Precision

Precision is the degree of agreement among repeated measurements of the same characteristic,

or parameter, and gives information about the consistency of methods.

Precision is expressed in terms of the relative percent difference (RPD) between two measurements (A and B), and is computed as follows:

$$RPD = \frac{A - B \times 100}{(A + B)/2}$$

Field and lab precision is measured by collecting blind (to the laboratory) field duplicate samples. KORDI ensures field precision by taking field duplicates at least once a year (section 4.2 and Table 4.1-4.2). Charts are produced by analysts to document accuracy and precision in their testing. These charts are kept in the laboratory for data validation purposes.

6.1.4 Quality Control

Once a year, the KORDI QA Officer will perform replicate analysis of all parameters. Variation of duplicate values for each parameter must not exceed the range of precision and accuracy discussed in the section 4.1 and Table 6.1. Any problems found with data collected are noted on the data sheets and in laboratory logbooks. Any changes to data are initialed by Project Quality Assurance Officer.

Table 6.1 Parameter, approved methods, precision and accuracy values

Parameter	Approved Test Procedures	Precision	Accuracy
Temperature1	APHA 2550	< 1.0℃	0.003(℃)
Salinity2	APHA 2510	< 1%	0.003(mS/cm)
Dissolved Oxygen3	APHA 4500-O G	0.05ppm	0.1ppm
pH4	APHA 4500-H+ B	0.1	0.02
TSS5	APHA 2540B	6.0mg/L	
DOC6	JGOFS (UNESCO, 1994)	< 10	< 5
POC7	JGOFS (UNESCO, 1994)	< 10	< 5
Phytoplankton8	Pouneva I (1997)	< 5	< 5
Zooplankton9	APHA-804C (1985)	< 5	< 5
Heterotrophic Bacteria10	JGOFS (UNESCO, 1994)	< 5	< 5
*Escherichia coli (E. coli)*11	3MTMPetrifilmTM Plate manual.	< 5	< 10
Enterococcus group12	Merk co. manual	< 5	< 10
*Vibrio cholerae*13	Merk co. manual	< 5	< 10

Footnotes

1 APHA, 1995. Standard Method for the Examination of Water and Wastewater, American Water Work Association and Water Environment Federation 19th Edition Washington D. C. 2-59 pp. [reference A1-3]

2 APHA, 1995. Standard Method for the Examination of Water and Wastewater, American Water Work Association and Water Environment Federation 19th Edition Washington D. C. 2-47 pp. [A1-4]

3 APHA, 1995. Standard Method for the Examination of Water and Wastewater, American Water Work Association and Water Environment Federation 19th Edition Washington D. C. 4-102 ~ 4-104 pp. [A1-5]

4 APHA, 1995. Standard Method for the Examination of Water and Wastewater, American Water Work Association and Water Environment Federation 19th Edition Washington D. C. 4-65 ~ 4-69 pp. [A1-6]

5 APHA, 1995. Standard Method for the Examination of Water and Wastewater, American Water Work Association and Water Environment Federation 19th Edition Washington D. C. 2-56 pp. [A1-7]

6 JGOFS Protocols-June 1994, Chapter 16, Determination of Dissolved Organic Carbon by a High Temperature Combustion/Direct Injection Technique. pp. 104-118 [A1-8]

7 JGOFS Protocols-June 1994, Chapter 15. Determination of Particulate Organic Carbon and Particular Nitrogen. 101-103 pp. [A1-9]

8 Pouneva I. 1997, Evaluation of algal culture viability and physiological state by fluorescent microscopic ethods. Bulg J Plant Physiol 23:67-76. [A1-15]

9 APHA, 1985. Standard Method for the Examination of Water and Wastewater, American Water Work Association and Water Environment Federation 16th Edition Washington D. C. 742 – 748 pp. [A1-2]

10 JGOFS Protocols-June 1994, Chapter 18. Determination of Bacterioplankton Abundance. 125-127 pp. [A1-10]

11 3M Company, 2004. 3MTM PetrifilmTMPlate Certificate, Recognitions and Validations (on line), http:// www.3m.com/kr/microbiology/petri-03ecoli.htm [A1-1]

12 Merk KGaA. 2002. Membrane-filter Entrococcus Selective Agar Acc. To SLANETZ and BARTLEY (on line), http://service. Merk.de/microbiology/tedisdata /prods/4975-1_05262_0500.html [A1-13]

13 *Vivrio cholerae*: Merk KGaA. 2003. TCBS Agar (Vibrio Selective Agar) (on line), Merk.de/microbiology/ tedisdata /prods/4973-1_10263_0500.html [A1-14]

6.2 Relevant Chemical Analysis

At least quarterly, SGS Testing Korea Co., Ltd QA officer will perform replicate analysis of all parameters. Variation of duplicate values for each parameter must not exceed the range of precision and accuracy listed in Table 6.2. Any problems found with data collected are noted on the data sheets and in laboratory logbooks. Any changes to data are initialed by the project quality assurance officer.

Table 6.2 Parameter, approved methods, precision and accuracy values

Parameter	Approved test procedure	Precision (RPD)	Accuracy (% R)
Bromide ion (Br^-)	USEPA 300.0	≤25	75~125
Fluoride ion (F^-)	USEPA 300.0	≤25	75~125
Bromate (BrO_3^-)	USEPA 300.0	≤25	75~125
Nitrate (NO_3^-)	USEPA 300.0	≤25	75~125
Sulfate (SO_4^{2-})	USEPA 300.0	≤25	75~125
TOC	USEPA 415	<30	75~130
COD	USEPA 410.4 (Hach 8000)	≤25	75~125
TCE	USEPA 8260	≤20	50~150
PCE	USEPA 8260	≤20	50~150
THMs	USEPA 524.2	≤20	50~150
$HAAs_5$	USEPA 552.2	<30	70~130
TOX	USEPA 9020	≤20	50~150
TRO	USEPA 330.5 (Hach 8167)	< 30	NA
Hydrogen peroxide	Fluorometric method	< 30	85-115

All the data generated for this project will be evaluated on the basis of its precision, accuracy, completeness, representativeness and comparability. Any data falling outside of the

established acceptance criteria for these five quality control parameters will be rerun after the potential sources of error have been investigated, corrected and documented. SGS Testing Korea Co. Ltd and Yonsei University will follow its routine quality assurance program to accomplish these quality assurance goals and will incorporate any additional quality control protocols.

6.2.1 Precision

Analytical precision is an important component of overall data accuracy since it is measure of how far an individual determination may be from the mean of replicate measurements. If the precision of an analysis is poor, there is a good probability that the reported result will differ substantially from the true value even if there are no systematic errors leading to bias in the final result.

Precision for this project will be evaluated by analyzing a duplicate sample at a 10% frequency interval and evaluating the relative percentage difference between the duplicate determinations. The relative percentage difference must lie within established acceptance criteria to be considered valid.

6.2.2 Accuracy

The analytical accuracy term referred to here, is a measure of analytical bias due to systematic errors. A measure of this bias along with a measure of the precision will present the overall accuracy of the result.

Bias for this project will be evaluated by analyzing a spiked sample at a 10% frequency interval and evaluating the percentage recovery. The percentage recovery is calculated in accordance with the following equation which corrects for any dilution due to the volume of the spike:

$$\% \text{ recovery} = \frac{(ET - A(T - B))x100}{BC}$$

Where, A = Original sample concentration before spike

T = Total sample volume after spiking

B = Spike volume used

C = Concentration of spiking solution

E = Final sample concentration after spike

The relative percentage difference must lie within established acceptance criteria to be considered valid.

6.2.3 Completeness

The characteristic of completeness is a measure of the percentage of contract specified data which is valid data. Valid data is obtained when all of the quality control parameters for the analytical run fall within the acceptance criteria. If quality control parameters are not met, the cause will be identified, corrected and documented and the sample will be rerun. If insufficient sample remains for reanalysis or the holding time has expired, the project manager will notify PANASIA Co., Ltd and relevant project managers.

6.2.4 Representativeness

All sample aliquots which are analyzed must be representative of the bulk sample from which they are taken. Representativeness is achieved for aqueous samples by inverting the sample two times before removing an aliquot. More vigorous mixing is not permissible due to the volatile nature of the organic constituents.

6.2.5 Comparability

The characteristic of comparability determines whether analytical conditions are sufficiently uniform for each analytical run to insure that all of the reported data will be consistent. This requires temporal stability, uniform analytical and quality control protocols will be closely adhered to for each analytical run.

6.3 WET Test

The purpose of this section is to document the Data Quality Objectives (DQOs) of the project. In addition, performance criteria will be established for the planning process and measurement system for the testing. All tests at the NeoEnBiz will be performed under the DAU GLP system of quality management controls for laboratories and research organizations, to ensure the consistency and reliability of laboratory testing results, and the purpose of this QAPP is to ensure that the principles of GLP are complied with and that the set DQOs are achieved.

6.3.1 Project Data Quality Objectives

The DQOs of each test under this study are designed to ensure that the data collected and analyzed are scientifically verifiable and valid, and can be used to determine compliance with the requirements of the IMO G9 Procedure.

Setting the DQOs involves a series of planning steps based on the scientific method that is designed to ensure that the type, quality, and quantity of toxicological data generated is appropriate for the intended application. DQOs are qualitative and quantitative statements derived from outputs of each step of the DQOs process that:

- Clarify the intended use of the data
- Define the type of data needed to support the decision
- Identify the conditions under which the data should be collected
- Specify tolerable limits on the probability of making a decision error due to uncertainty in the data.

6.3.2 Criteria for Measurement of Data

Criteria for Measurements of Data are the performance criteria: the accuracy, precision, comparability, representativeness and completeness of the tests. These criteria must be met to ensure that the data are verifiable and that project DQOs are met.

The objectives for accuracy, precision, comparability, representativeness and completeness are specified in the Study Plans for each test – as listed in Appendix 4.

All results will be recorded in field and laboratory logbooks. Additional sampling and analyses will be performed when results fall outside the specified ranges and when DQOs are not met. Any changes in DQOs will be submitted to DAU QA team for approval before implementation.

6.3.3 Accuracy

Accuracy is a measure of confidence that describes how close a measurement is to its "true" value. Accuracy includes a combination of random error (precision) and systematic error (bias) components that result from sampling and analytical operations.
Laboratory accuracy ranges are specified in the in the Study Plans for each test – as listed in Appendix 4 and depend on the parameter being measured. The Quality Assurance Officer will ensure the facility's laboratory accuracy.

6.3.4 Precision

Precision is the degree of agreement among repeated measurements of the same characteristic, or parameter, and gives information about the consistency of methods. Precision can be considered a product of the repetitiveness of monitoring.

6.3.5 Representativeness

Representativeness expresses the degree to which data accurately and precisely represents a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. Representativeness is a qualitative term that should be evaluated to determine whether in situ and other measurements are made and physical samples collected in such a manner that the resulting data appropriately reflect the media and phenomenon measured or studied. Representativeness in the laboratory is ensured by using the proper analytical and toxicity testing procedures; meeting sample holding times; and analyzing and assessing laboratory duplicates for the chemistry samples.

6.3.6 Comparability

Comparability is the degree to which data can be compared directly to similar studies. Using standardized sampling and analytical methods and units of reporting with comparable sensitivity ensures comparability.

6.3.7 Completeness

Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under normal conditions. Laboratory completeness is a measure of the amount of valid measurements obtained from all the measurements taken in the project.

6.3.8 Analytical Records

The analytical data results and intra-laboratory QA/QC results will be submitted by the QA Manager to the Project Manager or other designated contract person within the time frame from the completion of each sampling event specified in the relevant Study Plan.

6.3.9 Quality Control

Analytical quality control will be performed in accordance with the specified analytical methods and as discussed under the Quality Objectives and Criteria Section of this QAPP, as well as the SOPs and Study Plans for each specific test as listed in Appendix 4. The QA Manager and Inspector supported by the QA Officers are responsible for ensuring that all test procedures comply with this QAPP and the relevant SOPs and Study Plans.

7 REFERENCES

7.1 Reference for Bio efficacy Test and Chemical Measurement

[A1-1] 3M Company, 2004. 3M™ Petrifilm™ Plate Certificate, Recognitions and Validations (on line), http:// www.3m.com/kr/microbiology/petri-03ecoli.htm

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[A1-7] APHA, 1995. Standard Method for the Examination of Water and Istewater, American Water Work Association and Water Environment Federation 19th Edition Ishington D. C. 2-56 pp.

[A1-8] JGOFS Protocols-June 1994, Chapter 16, Determination of Dissolved Organic Carbon by a High Temperature Combustion/Direct Injection Technique. 104-118 pp.

[A1-9] JGOFS Protocols-June 1994, Chapter 15. Determination of Particulate Organic Carbon and Particular Nitrogen. 101-103 pp.

[A1-10] JGOFS Protocols-June 1994, Chapter 18. Determination of Bacterioplankton Abundance. 125-127 pp.

[A1-11] Jochem, F., 1999. Dark survival strategies in marine phytoplankton assessed by cytometric measurement of metabolic activity with fluorescin diacetate. *Mar Biol*,

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[A1-17] Hack Company, Chlorine Instruction Manual of Pocket Colorimeter II Analysis System. www.pollardwater.com/pages_product/LHC58700_Hach_Colorimeter2.asp

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7.2 Reference for Relevant Chemicals analysis

[A2-1] EPA 300.1, determination of inorganic anions in drinking water by ion chromatography

[A2-2] EPA 415.1, Organic Carbon, Total (Combustion or Oxidation) Approved for NPDES (Editorial revision 1974)

[A2-3] EPA 410.4, the determination of chemical oxygen demand by semi-automated colorimetry

[A2-4] Hach method 8000, Hach spectrophotometer procedure manual

[A2-5] EPA 524.2, Measurement of purgeable organic compounds in water by capillary column gas chromatography/mass spectrometry

[A2-6] EPA 8260B, Volatile organic compounds by gas chromatography/mass spectrometry (GC/MS)

[A2-7] EPA 552.2 determination of haloacetic acids and dalapon in drinking water by liquid-liquid extraction, derivatization and gas chromatography with electron capture detection

[A2-8] EPA 9020b. Total organic halides (TOX)

[A2-9] EPA 330.5 Chlorine, Total Residual (Spectrophotometric, DPD)

[A2-10] Hach method 1460, Hach spectrophotometer procedure manual Chlorine Tot-AVPP-Other-DPD-Eng-4000.fm

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7.3 Reference for Toxicity Test

7.3.1 Toxicity test guidelines

[A3-1] American Society for testing and Materials (2002) Standard Guide for Acute Toxicity Test with the Rotifer *Brachionus* (ASTM, vol. 11.05, method E 1440), 806-813.

[A3-2] American Society for testing and Materials (ASTM); Standard Guide for Conducting Static 96-h Toxicity Tests with Microalgae (ASTM E1218-97a).

[A3-3] USEPA 821/R-02/014 Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Marine and Estuarine Organisms Third Edition October 2002

[A3-4] Janssen et al., 1994. Cyst-based toxicity tests. VIII. Short-chronic toxicity tests with the freshwater rotifer *Brachionus* calyciflorus.

[A3-5] USEPA 821/R-02/014 Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Marine and Estuarine Organisms Third Edition October 2002

[A3-6] USEPA.1994, 600/R-94/025 Methods for Assessing the Toxicity of Sediment-associated Contaminants with Estuarine and Marine Amphipods

[A3-7] OECD Guidelines for the Testing of Chemicals, TG No. 202 (2004): Daphnia spp., Immobilisation test

[A3-8] OECD Guidelines for the Testing of Chemicals, TG No. 201 (2006): Freshwater Alga and Cyanobacteria, Growth Inhibition Test.

[A3-9] OECD Guidelines for the Testing of Chemicals, TG No. 203 (1992): Fish, Acute Toxicity Test

[A3-10] OECD Guidelines for the Testing of Chemicals, TG No. 211 (1998): Daphnia magna Reproduction Test

[A3-11] OECD Guidelines for the Testing of Chemicals, TG No. 215 (2000): Fish, Juvenile

growth test

[A3-12] OECD Guidelines for the Testing of Chemicals, TG No. 218 (2004): Sediment-water Chironomid toxicity test using spiked.

7.3.2 GLP guidelines

[A3-13] OECD Series on Principles of GLP and Compliance Monitoring (Jan 26, 1998), No. 1「OECD」Principles on Good Laboratory Practice」

[A3-14] OECD Series on Principles of GLP and Compliance Monitoring (Oct 29, 1999), No. 4「Quality assurance and GLP」

[A3-15] OECD Series on Principles of GLP and Compliance Monitoring (Sep 15, 1999), No. 6「The application of the GLP principles of field studies」

[A3-16] OECD Series on Principles of GLP and Compliance Monitoring (Sep 15, 1999), No. 8「The role and responsibilities of the study director in GLP studies」

PANASIA ISO9001 Certificate

DNV

DET NORSKE VERITAS

QUALITY SYSTEM CERTIFICATE

Certificate No. 0321-1998-AQ-SEO-KAB (Rev.1)

This is to certify that
the Quality Management System
of

PANASIA CO., LTD.

at

5-12 Block, Noksan National Industrial Estate, 1559-3, Songjung-Dong, Kangseo-Ku, Pusan, Korea

has been found to conform to the Quality Management System Standard:

ISO 9001:2000, KS A 9001:2001

This Certificate is valid for the following product or service ranges:

Design and Manufacture of Tank Level Gauging System, Draft Gauging System, Level Alarm System, Level Transmitter, Level Switches, Level Gauges and Tank/ Pressure/Temperature Monitoring System including Maintenance and Repair Services. Design, Development, Manufacture and Installation of Emission Reducing System.

Original Certification date:
June 3rd, 1998

Place and date:
Seoul, January 22nd, 2007

This Certificate is valid until:
May 21st, 2009

for the Accredited Unit:
DNV CERTIFICATION LTD

Compliance to the Standard in respect to the indicated scope is certified by the DNV approved registered Team Leader

Kyo-Haeng Cho
Lead Auditor

In-Kyoon Ahn
Management Representative

KAB
KAB-QC-10

Mark means that DNV Certification Ltd is appointed as Quality Assurance System Certification Body (No KAB-QC-10) by Korea Accreditation Board(KAB)
Lack of fulfillment of conditions as set out in the Appendix may render this certificate invalid

DNVCertification-KCT-12-D

DNV Certification, Room 2109, Kyobo Bldg
1, Jongno 1-Ka, Jongno-Ku, Seoul 110-123
Tel:(02)723-7993~4 Fax:(02)723-7996

SGS KOLAS Certificate

No. 260 (1/6)

CERTIFICATE OF ACCREDITATION

Name of Laboratory : SGS Testing Korea Co., Ltd. Anyang Laboratory

Representative : Arthur Kwon

Address of Headquarters : 18-34, Sanbon-dong, Gunpo-si, Geonggi-do, KOREA

Address of Laboratory : 322 The O vally Bldg., 555-9, Hogye-dong
Dongan-gu, Anyang-si, Geonggi-do, KOREA

Duration : July 12, 2005 ~ July 11, 2009

Scope of Accreditation
(Scope of Accreditation is described in the accompanying Annex)

This is to certify that the above Laboratory is accredited as Testing Laboratory in accordance with the provisions of Article 23 of the National Standards Act.

These criteria encompass the requirements of ISO/IEC 17025:2005.

November 4, 2008

Nam, Insuk

Administrator,
Korea Laboratory Accreditation Scheme(KOLAS)

SGS NELAP Certificate

State of New Jersey

Department of Environmental Protection

Certifies That

SGS Testing Korea Co., Ltd.

Laboratory Certification ID # KO001

having duly met the requirements of the

Regulations Governing The Certification Of
Laboratories And Environmental Measurements N.J.A.C. 7:18 et. seq.

and

having been found compliant with the standard approved by the

National Environmental Laboratory Accreditation Conference

is hereby approved as a

Nationally Accredited Environmental Laboratory

to perform the analyses as indicated on the Annual Certified Parameter List
which must accompany this certificate to be valid

Expiration Date June 30, 2009

Joseph F. Aiello, Chief
Office of Quality Assurance

NJDEP is a NELAP Recognized Accrediting Authority

THIS CERTIFICATE IS TO BE CONSPICUOUSLY DISPLAYED AT THE LABORATORY WITH THE ANNUAL CERTIFIED PARAMETER LIST IN A LOCATION ON THE PREMISES VISIBLE TO THE PUBLIC

Dong-A University GLP Certificate

지정번호(Certification No.) 제 16 호

비임상시험관리기관 지정서
GLP Certificate

시 험 기 관 : 동아대학교병원 임상시험연구센터

Test Facility(ies) Name : Dong-A University Hospital Clinical Research Center

소 재 지 : 부산광역시 서구 동대신동 3-1

Address : 3-1 Dongdaesin-dong, Seo-gu, Busan Metropolitan City, Korea

대 표 자 : 최병무

President : Byeong Moo, Choi

운 영 책 임 자 : 이상화

Test Facility Management : Sang Hwa, Lee

시 험 의 범 위 : 반복투여독성시험(설치류)
유전독성시험 중 체외염색체이상시험
유전독성시험 중 체내소핵시험

Test Scope : Repeated Dose Toxicity Test (Rodent)
In Vitro Chromosomal Aberration Test
In Vivo Micronucleus Test

비임상시험관리기준 제4조에 의하여 비임상시험기관으로 지정하였음을 증명함.

It is hereby certified that the test facility(ies) was(were) inspected by the national compliance monitoring authority regarding compliance with the Principles of Good Laboratory Practice.

issue date 2007 년(yr) 07 월(month) 25 일(date)

식품의약품안전청

Commissioner, Korea Food and Drug Administration

Dong-A University GLP Certificate

지정번호(Certification No:) 제 16 호

비임상시험관리기관 지정서
GLP Certificate

시 험 기 관 : 동아대학교병원 임상시험연구센터

Test Facility(ies) Name : Dong-A University Hospital Clinical Research Center

소 재 지 : 부산광역시 서구 동대신동 3-1

Address : 3-1 Dongdaesin-dong, Seo-gu, Busan Metropolitan City, Korea

대 표 자 : 최병무

President : Byeong Moo, Choi

운 영 책 임 자 : 정민호

Test Facility Management : Min Ho, Jeong

시 험 의 범 위 : 단회투여독성시험(설치류)

유전독성시험 중 복귀돌연변이시험

Test Scope : Single Dose Toxicity Test (Rodent)

Reverse Mutation Test

비임상시험관리기준 제4조에 의하여 비임상시험기관으로 지정하였음을 증명함.

It is hereby certified that the test facility(ies) was(were) inspected by the national compliance monitoring authority regarding compliance with the Principles of Good Laboratory Practice.

issue date 2005 년(yr) 11 월(month) 10 일(date)

식 품 의 약 품 안 전 청

Commissioner, Korea Food and Drug Administration

Dong-A University GLP Certificate

지정번호(Certification No.) 제2007-12호

화학물질유해성시험연구기관 지정서

GLP Certificate

시 험 기 관 : 동아대학교병원 임상시험연구센터
Test Facility Name : Dong-A University Hospital Clinical Research Center

소 재 지 : 부산광역시 서구 동대신동 3-1
Adreess : 3-1 Dongdaesin-dong, Seo-gu, Busan Metropolitan City, Korea

대 표 자 : 최 병 무
President : Byeong Moo Choi

운영책임자 : 이 상 화
Test Facility Management : Sang Hwa Lee

시 험 의 범 위 :

- 급성경구독성시험(고정용량법), 급성경구독성시험(독성등급법), 아급성독성시험, 유전독성시험(복귀돌연변이시험, 염색체이상시험, 소핵시험) (유효기간 : 2007년 12월 6일부터). 끝.

Test Scopes :

- Acute oral toxicity(Fixed dose procedure), Acute oral toxicity(Acute toxic class method), Subchronic toxicity, Genetic toxicity(Ames test, Chromosome aberration test, Micronucleus test) (Validation : since December 6, 2007).

유해화학물질관리법 제14조, 동법시행령 제12조 및 화학물질유해성시험연구기관의 지정 등에 관한 규정 제4조에 의하여 화학물질유해성시험연구기관(GLP시험기관)으로 지정하였음을 증명함.

It is hereby certified that the test facility was inspected by the national compliance monitoring authority regarding compliance with the Principles of Good Laboratory Practice.

issue date 2007년(yr) 12월(month) 6일(date)

국립환경과학원장

Director, National Institute of Environmental Research

Dong-A University GLP Certificate

Certification No. 2007-2

GLP Certificate

Test Facility Name : Dong-A University hospital Clinical Research center

Address : 3-1 Dongdaesin-dong, Seo-gu, Busan Metropolitan City, 602-714, Republic of Korea

President : Byeong Moo, Choi

Test Facility Management : Sang Hwa, Lee

Test Scope : Acute oral toxicity, Subacute oral toxicity, Mutagenicity (Ames test, Chromosome aberration test, Micronucleus test) (since Dec. 11, 2007)

It is hereby certified that the test facility(ies) was(were) inspected by the national compliance monitoring authority regarding compliance with the Principles of Good Laboratory Practice.

Issue date December 11, 2007.

Director, Rural Development Administration

Dong-A University GLP Certificate

지정번호 제2007-2호

농약안전성시험연구기관 지정서

시 험 기 관 : 동아대학교병원 임상시험연구센터

소 재 지 : 부산광역시 서구 동대신동 3-1

대 표 자 : 최 병 무

운 영 책 임 자 : 이 상 화

시 험 의 범 위 : 급성경구독성시험, 아급성경구독성시험, 변이원성시험(복귀돌연변이시험, 염색체이상시험, 소핵시험)(2007년 12월 11일부터)

농약관리법시행령 제4조 및 농약안전성시험연구기관에 관한 규정 제4조에 의하여 농약안전성시험연구기관(GLP기관)으로 지정하였음을 증명함.

2007 년 12 월 11 일

농 촌 진 흥 청 장

KORDI KOLAS Certificate

No. 322 (1/2)

CERTIFICATE OF ACCREDITATION

Name of Laboratory : Korea Ocean Research and Development Institute

Representative : Yum, Ki-Dai

Address of Headquarters : 1270, Sa2-dong, Ansan, 426-744, Korea

Address of Laboratory : 391 Jangmok-ri, Jangmok-myon, Geoje-si, 656-830, Korea

Duration : June 11, 2007 ~ June 10, 2011

Scope of Accreditation
(Scope of Accreditation is described in the accompanying Annex)

This is to certify that the above Laboratory is accredited as Testing Laboratory in accordance with the provisions of Article 23 of the National Standards Act.

These criteria encompass the requirements of ISO/IEC 17025 : 2005.

June 11, 2007

Kapkong Choi

Administrator,
Korea Laboratory Accreditation Scheme(KOLAS)

KORDI KOLAS Certificate

9. Biological testing

9.006 Aquatic biology

Test method	Standard designation
APHA-804C : 1985	American Public Health Association (APHA)/Standard methods for the examination of water and wastewater/To ascertain if a motionless animal is dead, touch it gently with a sealed glass capillary probe
EPA-445.0 : 1997	Environmental Protection Agency (EPA)/In vitro determination of chlorophyll-*a* and pheophytin *a* in marine and freshwater algae by fluorescence

End.

KORDI Certificate of Accreditation as the Type Approval Test Organization of Ballast Water Management System

지정번호 제1호
Cert. No. 1

밸러스트수관리시스템 형식승인시험기관 지정서
Certificate of Accreditation as the Type Approval Test Organization of Ballast Water Management System

지정을 받는 자 Nominee	①명 칭(상 호) Name of Organization	한국해양연구원 Korea Ocean Research & Development Institute		
	②성 명(대표자) Representative	염기대 Yum, Ki-Dai	③주민등록번호 (법인등록번호) ID No	490906-1000525 (130122-0002126)
	④주 소(사업장) Address	대한민국 경기도 안산시 사동 1270 1270, Sa-dong, Ansan-si, Gyonggi-do, Korea (경상남도 거제시 장목면 장목리 391번지, 391, Jangmok-ri, Jangmok-myon, Geoje-si, Korea)		
⑤형식승인시험의 종류 Scope of Accreditation		육상시험 및 선상시험 Land-based testing and shipboard testing		

「밸러스트수관리시스템의 형식승인 등에 관한 잠정기준」 제6조제3항에 따라 이 지정서를 교부합니다.

This is to certify that the above Body is accredited as a Type Approval Test Organization in accordance with the Interim Regulation for Type Approval of Ballast Water Management System and IMO MEPC Res. 125(53).

2007년 8월 29일
August 29, 2007

해 양 수 산 부 장 관
Minister of Ministry of Maritime Affairs and Fisheries